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The SCIENTIFIC MONTHLY

VOL. LXXV NO. 3 SEPTEMBER 1952

What GENERAL ELECTRIC People Are Saying

The men whose statements appear below are engaged in research and development work on various types of control in G.E.'s General Engineering Laboratory at Schenectady, N. Y.

J. G. HUTTON

PLANT CONTROL: The control of processes by remote and automatic means may be said to have had its beginning with the birth of the electron tube and hence the electronics industry. The almost instantaneous receipt of an electric signal, even at a considerable distance from its source, and the ease with which many physical and chemical changes can be converted into electrical impulses, opened the way for automatic control even in the most complicated processes.

In the petroleum and chemical industries many attempts have been made in recent years to provide new and improved methods for determining accurately both qualitatively and quantitatively the composition of mixtures in either gaseous or liquid form.

Perhaps the most versatile, and as a result, the most useful of the methods, is that based on the principle that certain materials selectively absorb infrared radiation. By comparing an unknown mixture against a standard, analyses can be made. In the case of hydrocarbon mixtures the technique can not be extended beyond those containing six or more carbon atoms, however.

The mass spectrometer in contrast can be used for the analysis of most mixtures whose components are fully vaporized at a pressure of some 40 microns at normal temperature. Its range of usefulness may be extended by heating the sample introduction system, the upper temperature being limited only by the thermal properties of the material of the system. By this relatively simple expedient, hydrocarbon mixtures containing components with 40 carbon atoms have been analyzed. Except for the high initial cost, delicacy and bulk, the mass spectrometer would be directly useful for process control.

Such objections may be overcome by the use of a mass spectrometer utilizing the cyclotron resonance principle. The tube is positioned in a uniform d-c magnetic field and an rf voltage applied to suitable electrodes to produce a periodically varying electric field whose axis is perpendicular to the magnetic field. Ions are produced in the analyzer region of the tube by bombardment of neutral gas molecules with an electron beam whose axis is coincident with the magnetic field. Under the influence of the combined electric and magnetic fields, the ions are accelerated and have an orbit of increasing radius—an Archimedes spiral. When the natural period of an ion of given mass is equal to the periodicity of the electric field, the particle assumes a resonant condition and acquires sufficient radial displacement to be absorbed or collected by a suitably placed electrode. Particles of different mass, having a different natural period, will not resonate. As a result such particles will be out of phase with the electric field and will not gain sufficient energy to reach the collector. By varying the electric or magnetic fields, or both, ions, representative of all molecules in a gaseous mixture, may be separated and collected.

F. E. CREVER

BIT WEIGHT CONTROL: The improvements in control components and techniques of analyzing control systems in the past decade have made precise control of power equipment practical for industry generally. It is no longer considered sufficient to provide power equipment to augment man's efforts; rather, the convenience of automatic and precise control is often desired. Typical of this trend is the General Electric automatic bit weight control for rotary drilling. Not only does the system provide a means of handling the hundreds of thousands of pounds of piping, but also it provides an automatic system to regulate the weight on the bit and to limit the speed of the lowering of the bit. This is provided through two simple settings of the quantities involved on knobs provided for the operator. The system utilizes the regulating properties of the amplidyne generator controlling power equipment to perform these functions. More recently amplistats have been developed so that the advantages of static regulating equipment are being applied to the many control applications necessary to continued progress in industry.

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VOL. LXXV SEPTEMBER 1952 NO. 3

Contents

Salvage Logging, Junction South Fork Wilson River and Highway . . . . . Cover
(U. S. Forest Service photo)

Tillamook Burn . . . . . *Richard M. Highsmith, Jr.*, and *John L. Beh* 139

Roman Street at Night (*Verse*) . . . . . *Joseph Hirsh* 148

Food Production by Fungi . . . . . *Radcliffe F. Robinson* 149

Scientific Method and Social Science . . . . . *Russell L. Ackoff* 155

The Messiah in Indonesia and Melanesia . . . . . *Justus M. van der Kroef* 161

World Beyond Seeming (*Verse*) . . . . . *Mae Winkler Goodman* 165

Stream Pollution Control . . . . . *Richard D. Hoak* 166

Water Witching . . . . . *Evon Z. Vogt* 175

Science on the March:
The American Explosion . . . . . *Fenton B. Turck* 187

Book Reviews by *Arthur A. Allen, Gabriel P. Betz, R. C. Corley, Eduard Farber, Mason A. Hein, Paul A. Herbert, Karl Lark-Horovitz, Alfred McClung Lee, J. C. Malin, W. M. Mann, Margery J.* and *Lorus J. Milne, Roald A. Peterson, Percy L. Ricker, L. M. Roth, Karl P. Schmidt, Marjorie B. Snyder, George Springer, Rufus Suter, Ralph F. Wolf*, and *Albert Wolfson* 192

Letters 202

Association Affairs 204

Annual Meeting, AAAS, St. Louis, Missouri, December 26–31, 1952

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Science and Technology

(From the Month's News Releases)

Surface Protection

A cold-galvanizing compound may be used under any oil-base paint on iron and steel to insure complete rust protection. When applied to a ship's hull, it will prevent sea growth, corrosion, and electrolysis. Applied onto adhering rust, it induces the rusted area to create its own nonflaking coating, thus preventing rust creep. Within 40 minutes after application, it will be tackfree and within 48 hours will be completely dry.

A transparent liquid applied to stucco, glass brick, or cement is claimed to be the only exterior wall waterproofing compound that will withstand hurricane-driven rain. It has also proved resistant to acids, alkalis, and temperature extremes.

A ready-mixed aluminum paint will add a protective and decorative finish to furnaces, pipes, boilers, ovens, and other metal surfaces that must withstand up to 1600° of heat. The paint may be brushed, sprayed, or dipped, and air-dries within 30 minutes. Although best results are obtained when application is made on clean, dry surfaces, it may be applied to surfaces that are rusty, moderately greasy, or oily.

An enamel containing a nontoxic fungicide, for use in creameries and meat, food-processing, and poultry plants, has remained mildew-free on panels tested for more than 18 months in rooms where ordinary paint is profusely covered with mold within two months.

A plastic-spray coating is based on Vinylite resins and may be sprayed directly on interior walls of cinder or concrete blocks, completely sealing the surface. The coating may be applied in several thicknesses without change in appearance, thus giving extra protection for areas exposed to heavy wear. It is resistant to moisture, mold and mildew, oils, inks, salt spray, and most chemicals. Another type of resin-based coating may be used inside malt grain-steep tanks for long-lasting protection.

Horticultural Research

S. L. Emsweller, of the USDA's huge Plant Industry Station at Beltsville, Maryland, has developed three new varieties of chrysanthemums that will be listed in nursery catalogues as soon as a sufficient quantity of stock is available. Thor, a semidouble dark lavender, is a dwarf plant with flowers 2½ to 3 inches across. At Beltsville it blooms from mid-September into October. The double, lemon-yellow flowers of Glorious are borne on stems 36–42 inches high, and those of White Cap, a semidouble white, on stems 20–26 inches high. Flowering period for both is early October.

While mums are being encouraged to grow higher, sunflowers are being developed that will stand only 4–6 feet off the ground, instead of 8 feet. Object of sunflower variety trials at the University of California's Imperial Valley Field Station is to grow a commercial sunflower with the usual big, seed-laden heads but short enough to be harvested by combine.

Make Movies in the Dark

Eastman Kodak, in tests conducted at the University of Rochester with its new Spectroscopic I-N Film, has made successful motion pictures of audience reactions when house lights in a theater were dimmed to 1/70th normal room illumination. The film can be used in any standard 16mm or 35mm motion picture camera accepting roll film or 16mm magazines, but lengths over 100 feet will require the acceptance of spliced rolls.

The Day and the Date

Not that the day is important, but the Declaration of Independence was signed on a Thursday, and the next President of the United States will be inaugurated on a Tuesday. Questions about any day and date from 1753, the year the Gregorian calendar was adopted, to 2059 can be answered in a matter of seconds with the help of a perpetual calendar invented by Arthur A. Merrill, a G-E engineer. The Merrill calendar is so simple that the 3684 months represented can be compressed to fit on the front and back of a wallet-sized card and still be clearly legible.

British Radiochemicals

Nuclear Instrument & Chemical Corporation has signed an agreement with the British Ministry of Supply to distribute in this country radioactive compounds produced in Britain. The agreement covers such special compounds as DL-3-phenylalanine-2-C^{14} and 2:4 dichlorophenoxyacetic acid-1-C^{14}.

Dual Recorder

Without actually mixing the sounds, a new type of machine permits synchronous recording of two different sounds on the same tape, either simultaneously or at different times. Each may be erased, corrected, changed in relative volume, or copied without affecting the other. Among suggested uses are practice in responding to cued situations and in playing to an accompaniment. Or a language instructor may prepare a master recording of selected phrases on one track, leaving pauses for student response. While listening to the recording, the student records his imitation or translation; then, playing both tracks together, he hears the teacher's voice, followed immediately by his own response. In conference recording the machine is useful in separating conflicting voices, thus increasing transcription efficiency.

Less Friction

Ball-bearing devices, in sizes from 5/8 to 1/8 inch

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in diameter and from 5/8 to 1 13/16 inches in length, which can be glued into woodwork, will do away with frictional drag on sliding surfaces. A flanged type permits the unit to be set at a predetermined height above the surface. Prices range from 20 to 45 cents.

Testing

A method of bending up the corners of steel sheets mechanically and making an accurate measurement of the drawing quality of cold-reduced steel has been worked out by Jones & Laughlin metallurgists. Their Flex-Tester requires no specimen preparation or coupon cutting and will reduce costs of labor and material. In strip mills the tester may be used to determine stretcher strain characteristics.

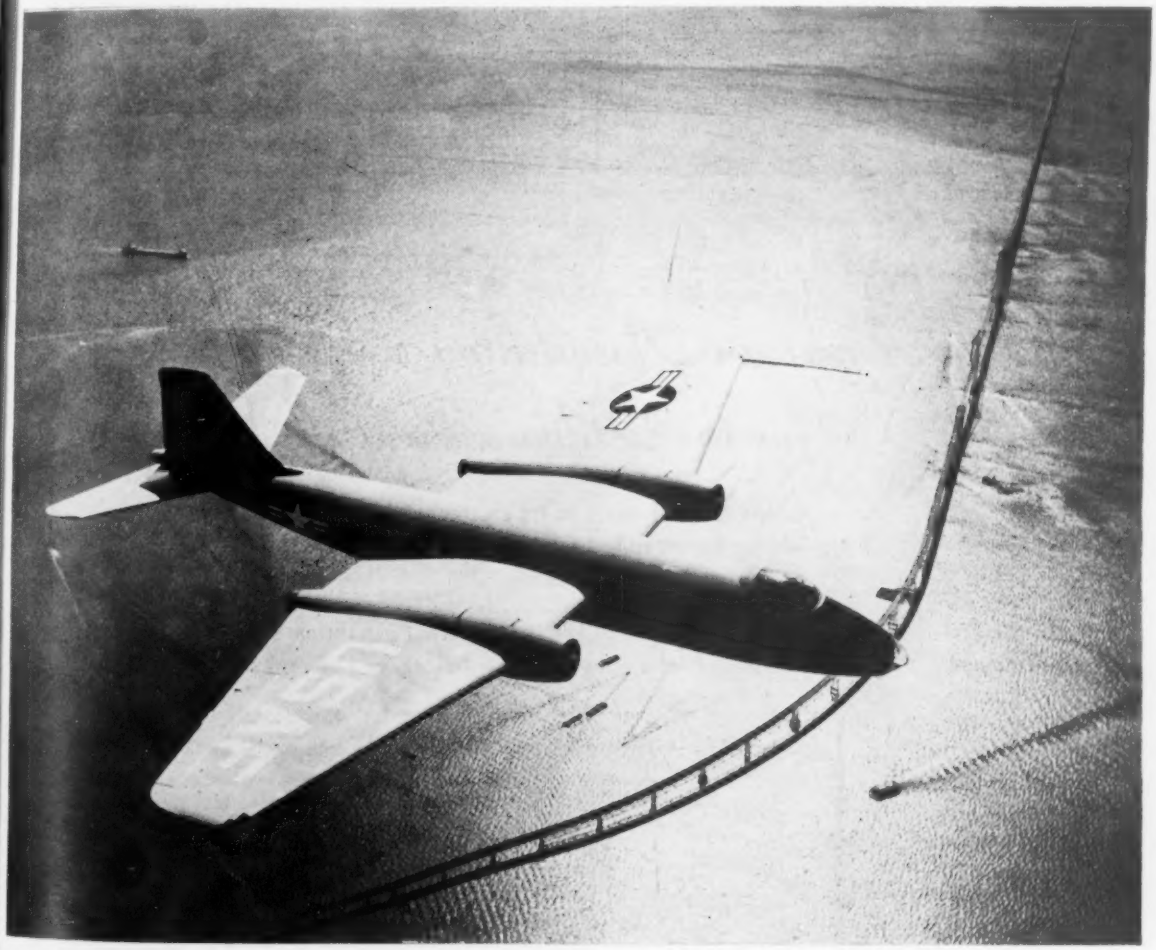
Thermocolors, developed in the late thirties by I. G. Farben Industries, are now available in this country for the testing of temperatures on solid bodies in a range from 104° to 1508° F. Each color comes as a powder which is stirred with ethyl or methyl alcohol and very thinly coated on any surface either by brush or spray gun. Fourteen of the colors make a single change at designated temperatures, and 12 others are capable of two, three, or four color changes at different temperatures. Three other colors will shortly be available to test temperatures from 1500°F. to 2000° F.

A petroleum-based type of ink for nondestructive detection of both subcutaneous and surface flaws in ferrous metals requires magnetizing the test piece and pouring the ink over its surface. A fluorescent crack detection ink for use with light metals, nonferrous alloys, and stainless steels shows up cracks in a brilliant green when they are examined under ultraviolet light.

Bausch & Lomb Optical Co. is offering a free consulting service to demonstrate how various models of its new industrial stereomicroscope can be built into machine, assembly, and inspection setups to speed processing, reduce rejects, and diminish employee fatigue.

Double Action

Squeegee-Scraper has one hard scraping edge for removing ice, sleet, snow, bugs, and mud from glass and a soft rubber edge for removing fog, frost, steam, water, and splatter. Inexpensive.



English Electric-built Canberra twin-jet light bomber over new Chesapeake Bay Bridge, recently opened to traffic. Bridge connects eastern and western shores of Maryland.

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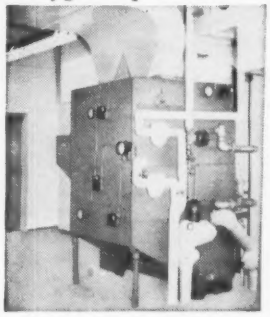

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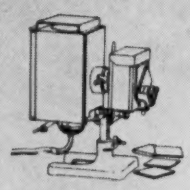
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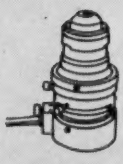
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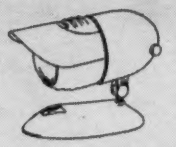
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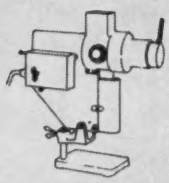
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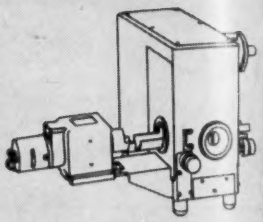
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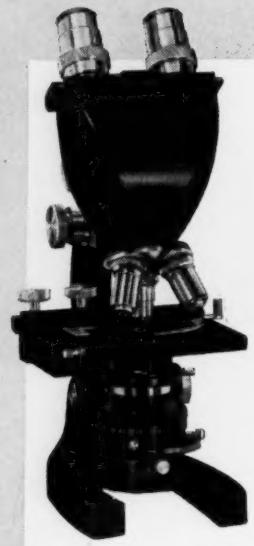

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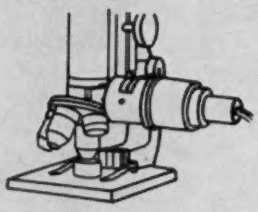
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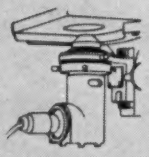
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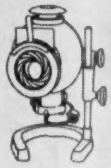
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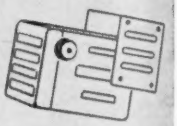
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SEPTEMBER 1952

Tillamook Burn: The Regeneration of a Forest

RICHARD M. HIGHSMITH, JR., and JOHN L. BEH

Dr. Highsmith is a native of the Pacific Northwest. He took his Ph.D. in geography at the University of Washington last year, after interrupting his education to serve as a U.S.M.C. officer in the Pacific and Asiatic theatres. He has been at Oregon State College since 1947, on the staff of the Department of Natural Resources. The junior author is a graduate student in the same department.

THE Tillamook Burn, which encompasses 355,397 acres of forest land in the Coast Range of Oregon, is the most famous fire-killed timber area in western North America. Twenty years ago it contained one of the finest stands of growing timber in the Douglas fir region, and loggers were only beginning to harvest the prime crop. Then came the great fire of 1933. This, and subsequent fires during the summers of 1939 and 1945, killed an estimated 12–13 billion board feet of timber.*

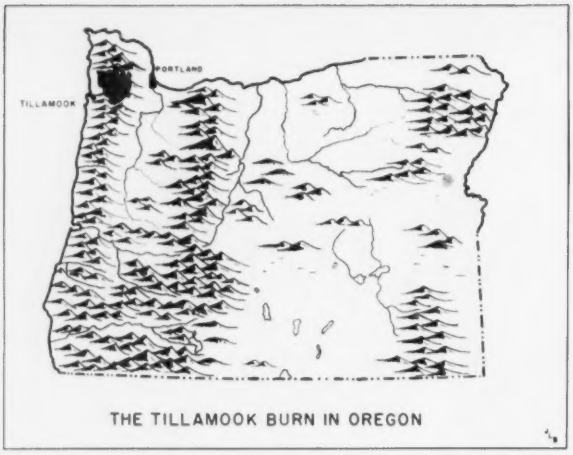
Logging of the burned trees began in the middle 1930s. The stimulus was provided by several factors, including (1) increased lumber demands and high prices, (2) a decrease in the timber-standard requirements of forest products industries, and (3) improvement of access by the construction of Wilson River Highway through the Burn. In recent years the rehabilitation program has also provided some stimulus to logging in the area. By 1952, 8–10 billion board feet had been salvaged. If favorable prices continue, it is estimated that an additional 2–3 billion board feet can be taken from the Burn.† The remainder is probably doomed to decay because of small size, excess breakage, and the ravages of insects and disease.

The land of the Burn is suited primarily for forestry. Severely dissected terrain, cool, moist climate, and podsolic, fire-altered soils restrict agriculture to minor cultivation on the alluvial bottom lands near the perimeter, and to limited livestock grazing on the lower slopes. Recreational values are beginning to be exploited with the building of summer homes and permanent dwellings along the main highway. The future of the area, however, is in the growing of trees. Plans and programs are currently being directed toward the regeneration of the forest through seeding, planting, and controlled management designed to protect the growing forest and provide continuous harvest.

The physical setting. The Tillamook Burn is comprised of portions of three northwestern Ore-

* According to R. M. Kallander, rehabilitation director of the Tillamook Burn, Salem, Ore., 1951.

† Darrell H. Schroeder, forester, Stimson Lumber Company, Forest Grove, Ore.



THE TILLAMOOK BURN IN OREGON

Figure 1.

gon counties: Tillamook, Washington, and Yamhill (Fig. 1). The entire area falls within the Oregon Coast Range, a low anticlinorium of Tertiary formations, broken occasionally by igneous intrusions. The maximum elevations at the crest are approximately 3000 feet some thirty miles inland. Three broad folds are apparent, but each is maturely dissected, and the land is predominately in slope (Fig. 2). Residual soils of varying depths mantle the area; these are largely derived from the Tillamook volcanic series found in the east and from Oligocene sandstones of the Astoria formation in the west.[1] Patches of alluvium are found in the lower valley bottoms.

Five major streams traverse the Burn. The Wilson, Trask, Kilchis, and Miami rivers flow westward, and the Tualatin River flows to the east. The current absence of forest litter and the limited amount of natural vegetation have had considerable influence on runoff. Erosion in the watersheds has been accelerated, and the sediment load of the streams has increased. Owing to the limited water-holding ability of the charred soils, there is a tendency for the small tributaries to lose volume during the summer, and some actually become dry.

Proximity to the Pacific Ocean, with prevailing winds from the west, results in a moderate climate over the Burn. Winters are generally mild and rainy, and summers cool and relatively dry. Summer temperatures average 60°–64° F., and winters 34°–38° F. Seasonal extremes rarely go above 85° or below 20°. The frost-free period ranges from 140 to 180 days. Precipitation varies from 80 inches on the lower slopes to 120 inches on higher, exposed elevations, with about four fifths of the total coming between October and March.[2] Snow can be expected every winter, but only on the higher elevations does a snow cover persist. Relative humidity in summer is usually in excess of 40 per cent; however, it can be expected to drop below 30 per cent for a few days at a time in July, August, and early September.

Such climatic conditions are ideal for the growth of coniferous trees, and under virgin conditions the slopes were clothed with dense forests. Western hemlock and Sitka spruce were the characteristic trees on the western border within ten or twelve miles of the coast; noble fir and Pacific silver fir were found on some of the highest ridges; and the remaining areas supported mixed stands of Douglas fir, western hemlock, and western red cedar, with Douglas fir usually dominant. In general the saw timber stands were 300–600 years old, with trees averaging three to six feet in diameter and 200–250 feet in height.[3]

The successive burnings killed the conifers, and a pioneer vegetation has appeared; this is composed of Oregon alder, vine maple, and plants such as bracken fern, blackberry, salal, and salmonberry. Only Oregon alder is of economic importance, with potential utility in furniture manufacture.

Fires and fire destruction. Fire is imminent in the Douglas fir region when relative humidity drops below 30 per cent and remains low for any length of time. During such dry weather, logging operations are halted by law to minimize the danger. Nevertheless, few summers pass entirely without fire.

The Tillamook Burn has been the locale of several of the worst forest fires of modern history. Beginning in 1933, and following six-year cycles, the area has been ravaged by four devastating fires (Fig. 3). The first was the most serious conflagration.[4] This great fire started on Gales Creek, a tributary of the Tualatin River, on August 14, 1933 (Fig. 4). Relative humidity had dropped to 20 per cent and was accompanied by a drying east wind, but logging continued. Runners dispatched to close down logging operations were too late. Fire, started by friction from dragging a log, spread rapidly and in just eleven days had crowned through more than 235,000 acres of Oregon's best quality timber. In this period an estimated 11,828,712,000 board feet of timber were killed. Stumpage value on the 1952 markets would exceed $100,000,000.

In 1939 the fire-killed snags were again swept by blazes[4] which reburned a major portion of the area and, in addition, 28,180 acres of green timber. Damage included the burning of 834,220,000 board feet of previously undamaged timber and the killing of the remaining natural seed sources, as well as the young seedlings that had regenerated since 1933.

TABLE 1

THE TILLAMOOK FIRES*

Year	Acres Perimeter Area	Acres Unburned Area	Acres Burned Area	Board Feet Timber Killed
1933	257,120	21,527	235,593	11,828,712,000
1939	209,690	19,030	189,660 (28,180 green timber)	834,220,000
1945	182,370	2,240	180,130	—
1951	—	—	38,039	—
Total	360,882	5,485	355,397	12,662,932,000

* According to Oregon State Board of Forestry.

On July 9, 1945, fire a third time[4] enveloped the area, originating at two points, one on the south fork of the Wilson River and the other on the Salmonberry River. These fires burned for six weeks before being brought under control, and 180,130 acres were burned.

During the summer of 1951, two fires broke out in the Burn. These were not of the magnitude of the previous blazes, but nonetheless caused serious loss. A total of 38,039 acres was affected, and 10 million board feet of saw logs previously felled and awaiting transportation were destroyed.[5] No green merchantable timber was burned.

In these tragic fires, covering a period of eighteen years, Oregon has suffered a great resource loss (Table 1). Actual destruction of merchantable tim-

Fig. 2. A view eastward up the Wilson River showing the rugged terrain of the Tillamook Burn. (Photo by Oregon State Board of Forestry.)

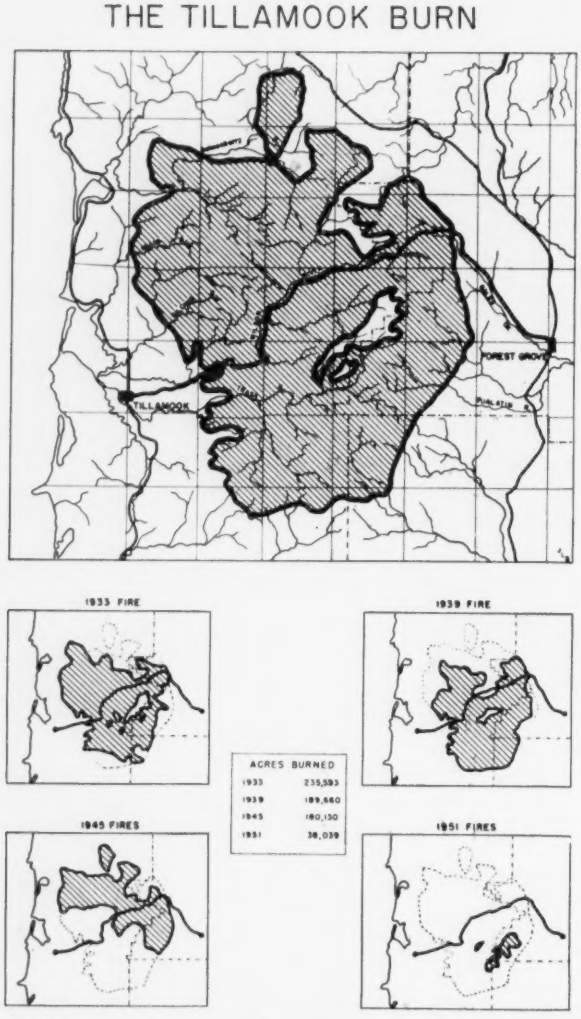


Figure 3.

ber by combustion was slight. Following the first fire the total merchantable volume was estimated to be reduced by only 4 per cent (Figs. 5 and 6). Soon after the trees were killed, however, deterioration set in, and its progress has accelerated with each passing year.[6] Further losses are associated with subsequent fires and with excessive breakage in felling.

Insects and fungi play a particularly devastating role. They work under similar conditions and at similar rates. The bark beetle was an early threat. This insect assisted in the deterioration by boring in the sapwood and loosening the bark, exposing the bole to other agents of deterioration, such as various fungi which attack the cellulose and lignin of the wood, causing brown and white rots. These diseases are progressive in nature and will eventually work through to the heartwood, completely destroying its merchantability. Sap worms (spined pine borers) have also caused considerable degrade in the burned timber. Today the heartwood, depending upon the diameter of the snags, is affected to depths of 4–10 inches. It is estimated that insects and disease have partially or completely destroyed about 30 per cent of the volume of timber on the Burn for commercial use. The bark beetles were destroyed in the 1939 fire, but the disease and sap worm attack and weather checking continue.

The sooner the remaining timber is harvested, the greater will be the yield of wood products. The waste ratio and, therefore, the logging cost increase with each passing year. Moreover, the fire hazards remain as long as the dead trees stand. The good logs must be harvested during the next ten to fifteen years or deterioration will have progressed beyond economic utility for lumber. Expansion in wood chemical industries could extend the period of usefulness and make it possible to salvage a much higher percentage of the dead timber.

Salvage. In recent years 300–400 million board feet of timber have been taken from the Burn annually. The majority of the saw logs are Douglas fir and western red cedar. The practicability of salvage depends upon several factors, including tree species and size, intensity of burn and reburn, degree of insect and fungus attack, position of the log in the tree, and the nature of the terrain.‡ The Douglas fir salvage has been based largely upon size of tree and elapse of time since killed. At present, butt logs 68 inches or more in diameter comprise the bulk of the harvest. The extreme western portion is not being logged because the spruce and hemlock have deteriorated beyond any practical use.[6]

An estimated 100 logging groups are operating in the Burn in 1952, varying in size from 2 to 120 men

‡ According to R. M. Kallander.

Fig. 4. The 1933 fire in virgin timber. (Photo by U. S. Forest Service.)

Fig. 5. Virgin Douglas fir timber killed by crown fire. Dense ground cover of fireweed and salmonberry. (Photo by U. S. Forest Service.)

(Fig. 7). The majority are small and are frequently working under contract to the larger logging companies or mills. The hazards in felling the timber are great, and utmost care must be taken. The trees are dry, and the upper limbs and bark are loose and are often dislodged by saw vibration. The top two thirds of the dead trees are usually badly broken when they strike the ground, and normally only the butt logs are hauled from the area (Fig. 8).

Tractor logging prevails except on the more rugged western slopes, where the high-lead system must be employed (Fig. 9). More than 90 per cent of the cut is milled beyond the perimeter of the Burn.[7] Logs are trucked from the western portion to Tillamook Bay plants and from the east to Forest Grove and either the Yamhill River or the Columbia River at Scappoose for rafting to mills in the Portland area.

The recovery and utilization of the fire-killed timber are of economic benefit to the entire Northwest by:

1. Permitting a higher income from timber products.
2. Prolonging the life of mills of nearby areas by supplementing local log supplies.
3. Providing an additional source of fine-grained, clear lumber.
4. Decreasing the necessity for cutting immature timber in other areas.

At the same time, the salvage program is reducing fire hazards on the burned-over land, providing better seed-bed conditions for the establishment of the new crop, and providing income from the area while the rehabilitation programs are being put into effect.

Rehabilitation.[8] Following the 1945 fire a study of the problems of the Tillamook Burn was made by a special committee appointed by the governor of Oregon. The findings were that the area was not satisfactorily restocking itself, and recommendations were made for immediate action in setting up a rehabilitation program, with cost to be met by a bond issue, backed by state credit and to be retired insofar as possible by sale of timber from the area. The plan received approval in 1948, and the following year the legislature passed the enabling act that set up the legal machinery to carry out the work. The first sale of Rehabilitation Bonds was authorized by the State Board of Forestry on July 18, 1949.

Groundwork for rehabilitation had been completed previously. Techniques of aerial seeding, of planting, rodent control, corridor development, and allied activities had been developed. Much basic information was needed, however, before the actual job could begin. Section lines had to be surveyed, and location of state lands determined.§ Preplanting surveys were required to determine the nature and extent of natural restocking, terrain, soil, cover conditions, and the concentration of snags. Analysis of this material indicated the reforestation needs of each area and their adaptability for aerial seeding, hand planting, or spot seeding.

§ In 1952 Tillamook Burn ownership is as follows: federal, 5 per cent; state, 70 per cent; county, 2 per cent; municipal, 1 per cent; and private, 22 per cent.

Fig. 6. Dead timber six years after the fire. Note the dense cover of fireweed. (Photo by U. S. Forest Service.)

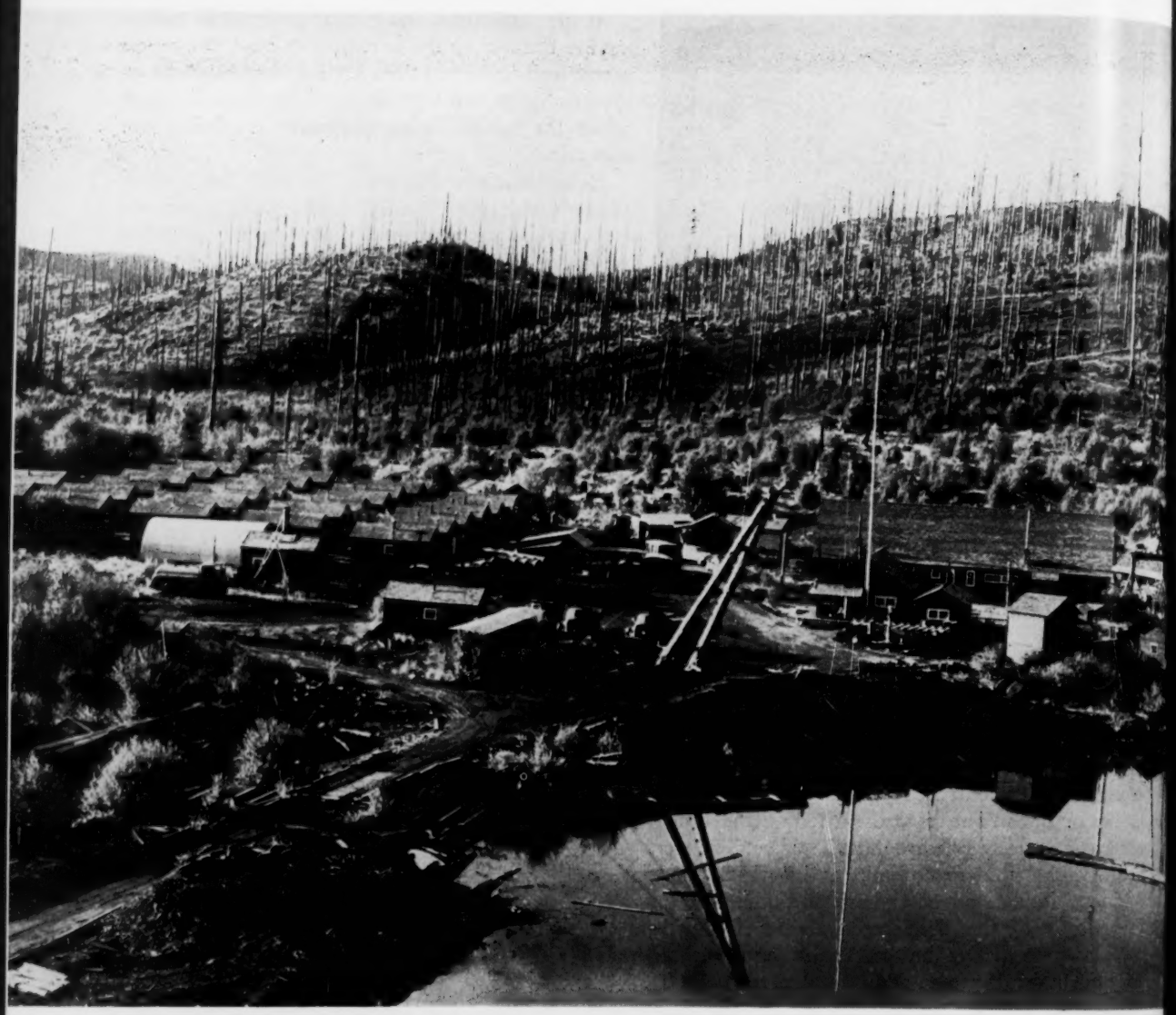


Fig. 7. Lumber camp of the Stimson Lumber Company, one of the three largest operators in the Burn. (Photo courtesy Stimson Lumber Company.)

Surveys were also necessary to determine the need and location of access roads, snag-free corridors, lookouts, and sites for fire suppression crews.

Rehabilitation work is being carried on only on state-owned land, which now includes 70 per cent of the total area of the Burn. There is a good possibility that the remaining county lands, which comprise 2 per cent of the burned area, will be acquired by the state sometime in the future.

Reforestation had been established on nearly 40,000‖ acres by April 1952, including 29,640 acres seeded from the air and approximately 10,000 acres planted with seedlings (Fig. 10). Aerial seeding is done in the fall, and the planting from early November to early April (Figs. 11 and 12). Tree planting costs have averaged $17.23 per acre with spacing of seedlings six by eight feet, whereas the cost of aerial seeding of one-third to one-half pound per acre has averaged $5.00.¶ The 1951 planting utilized the labor of inmates of the State Prison, as well as voluntary groups, including naturalist organizations, public school students, 4-H Clubs, and Boy Scouts.

A fire protection program has been set up for

‖ According to R. M. Kallander.

¶ The State Board of Forestry maintains a Forest Tree Nursery near Corvallis. About 3,000,000 trees are produced annually.

the Burn. Sixteen lookouts with radio communications will be in operation by 1953 in and around the area. A network of fire and access roads is being constructed, and snag-free corridors are being established. At present, construction is under way on the main north-south access road and snag-free corridor, separating the main body of the Burn from the watersheds of the Hillsboro, Forest Grove, Gaston, Yamhill, Carlton, and McMinnville districts. A second main corridor will extend east-west along the Wilson River Highway to divide the area in half. Secondary east-west combined access roads and corridors are being constructed from points originating on the main north-south break to further subdivide the body of the Burn. All breaks will be at least one-quarter mile wide and will follow the natural divides. Twenty-eight miles of snag-free corridors and 84 miles of access roads had been constructed through 1951, giving protection to the newly reseeded and planted area.**

The state has been expending $400,000 annually on the rehabilitation. Appropriations resulting from six bond issues, totaling $1,700,000, are sufficient to carry the program through 1952, when new financing will be required. It is estimated that complete restocking will require a minimum of thirty-five years.

Up to the present there has been little planting or seeding done by private owners, who control 22 per cent of the land. There is a trend, however, toward concentration of ownership by large enterprises interested in long-range planning. These large organizations are almost 100 per cent behind the rehabilitation program. The interest currently displayed indicates that much of the private land may be handled silviculturally as a tree farm.

Wildlife. In late 1933 wildlife in the Burn was virtually nonexistent, either having perished in the fire or escaped to the safety of the surrounding area. The successional growth of such plants as vine maple, salal, and various berries provides excellent fodder for the herbivores, as well as feed for bears. Re-establishment of the deer herds was ac-

** Oregon State Board of Forestry.

Fig. 8. End of a Douglas fir log in salvage cutting. Note rotten sapwood. (Photo by U. S. Forest Service.)

Fig. 9. Tractor logging. (Photo courtesy Stimson Lumber Company.)

complished by closing the Burn to hunting from 1933 to 1942.†† Fur bearers and birds are about at their prefire level, all being present in populations equaling or exceeding prefire numbers. Coyotes are new to the area, and the growing abundance of several species of rodents is causing some concern because of their seed-eating habits.‡‡ In general, however, both mammal and fish populations are progressing in a satisfactory manner. A

†† Based upon authors' questionnaire, filled in by Wesley Batterson, Oregon State Game Commission, Tillamook, Ore., 1951.

‡‡ Rodents may be controlled most effectively by Arosan Poison Seed Pellets, which are broadcast over the infested areas. These pellets are painted green to forestall their consumption by birds.

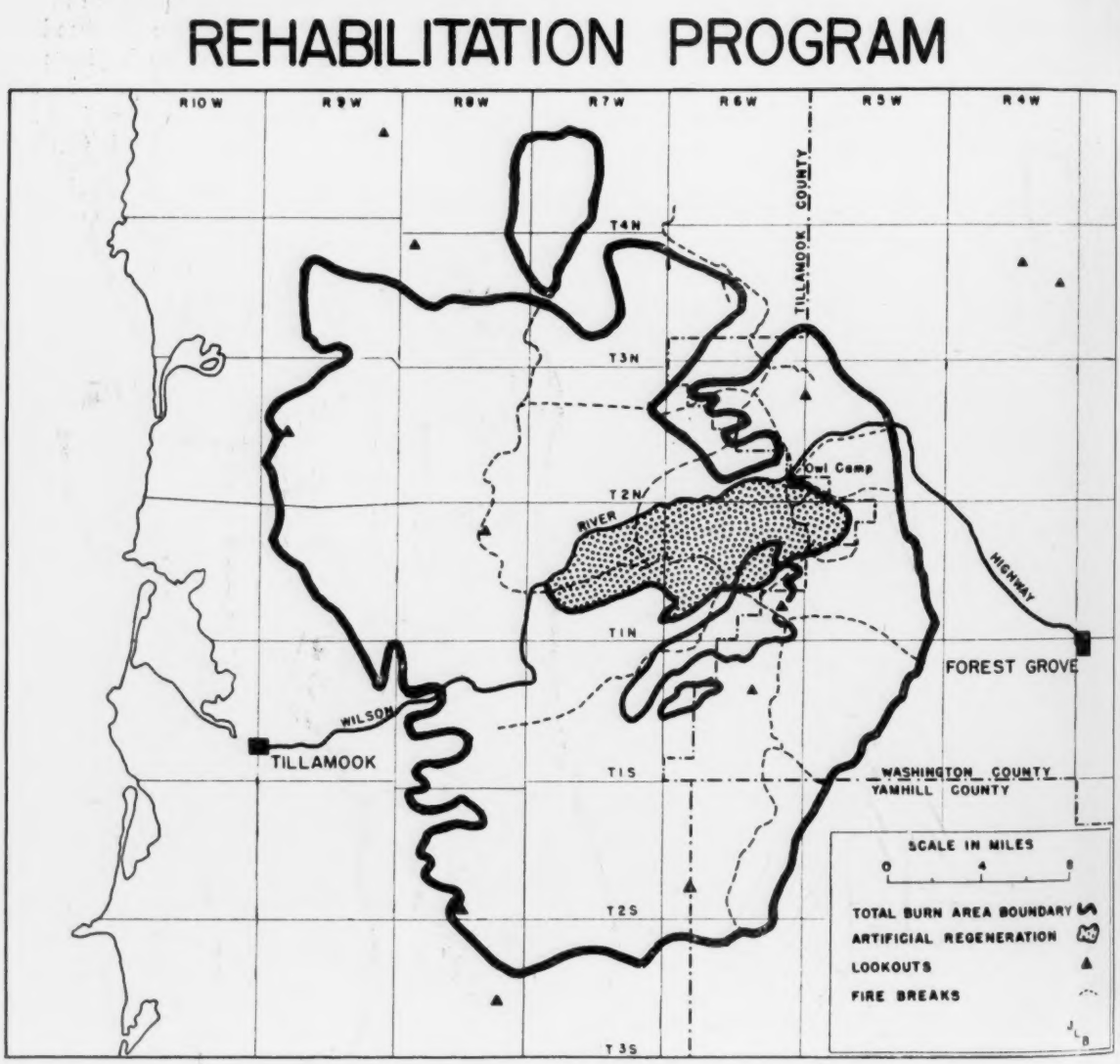


Figure 10.

Fig. 11. Helicopter seeding operation—Tillamook Burn Area. (Photo courtesy Oregon State Board of Forestry.)

Fig. 12. Portland high school students yearly have a program of tree planting in the Tillamook Burn. (Photo courtesy Portland Public Schools.)

balanced wildlife for the future should be assured by a program of habitat and sustained-yield wildlife management formulated and directed by the Oregon State Game Commission.

The rehabilitation of the Tillamook Burn is of utmost significance to Oregon. Environmental conditions prevent other productive uses of the area but at the same time are ideal for the growth of trees, a resource upon which a large segment of the state's economy depends. It is imperative that the program for regeneration and protection now under way shall continue without interruption. Under present utilization standards, the logging of standing snags will continue to bring income from the Burn for, at the most, fifteen years. There will then necessarily follow several decades of inactivity, except for possible cutting of Oregon alder for hardwood furniture or other uses. Thinning of plantings now being made can begin in about forty years. This selective harvest will provide a transitional pole and pulpwood industry. If present trends continue, the Burn should support a permanent timber industry harvesting about 262,000,000 board feet annually by 2026.§§

§§ Estimate of Vernon Larsen, Tillamook County Assessor.

Thus, this area of great forest tragedy should, through the foresight, planning, and activity of man, again become productive and complete in every ecological detail. The regeneration of the Tillamook Burn is a large-scale experiment in rehabilitation of forest resources that may well serve as the prototype for other fire-killed areas in the world.

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ROMAN STREET AT NIGHT

Sounds come closer to the core
Of what a street is
Or means—
More than its name or history.
And so it is in Rome
Where plump-faced cobblestones
Are open-mouthed with laughter,
At the clicking heels of passersby
That vie with horses' hoofs,
And these with wheels,
Some iron-rimmed that crash
And others rubber-wrought that screech,
But these are background instruments
For murmurs, talk, a sigh,
A wild, but oft a gentle song,
That make the nocturne street
A special kind of symphony.

Joseph Hirsh

Rome
6 July 1952

Food Production by Fungi

RADCLIFFE F. ROBINSON

Dr. Robinson went to Battelle Memorial Institute in 1941 and is now assistant supervisor of biological research. During the war he served as a civilian with the Atomic Energy Commission, and since that time has supervised research on fundamental and industrial problems in the field of microbiology. In addition to a study of algae and fungi as food, his current investigations include a detailed study of irradiation sterilization for industrial purposes.

THE need for an abundant supply of food is universally recognized. This supply must not only be great enough to support the population of a country during normal times, but must also provide substantial amounts for export to countries where sufficient food cannot be grown. In addition, it should provide large quantities for storage to carry the population through periods of crop failures, and, finally, should provide reserves for use in the event of war or other world catastrophe. Methods of increasing our food production are constantly being considered, such as opening of new lands to be used in an efficient manner, soil and water conservation, improved agricultural technology, and the development of more productive varieties of plants. Grassland and livestock improvement have received considerable attention.

Sir John Russell and many other modern-day scientists agree that the needed food for at least half a century to come can be supplied by developing conventional methods. Of the undeveloped resources, it may be mentioned that 0.6 per cent of the world's land, reclaimed by irrigation, feeds 25 per cent of the world's people. Vast areas of unproductive land throughout the world, if irrigated, could raise food production far above present levels. Of the present fish crop of 37 billion pounds per year, 98 per cent comes from the waters of the Northern Hemisphere. The far more extensive waters of the Southern Hemisphere are an almost limitless source of protein and fat. Fish farming, as practiced in India, China, and Japan, produces 4–8 tons of protein food per acre per year—far more than any other form of animal husbandry. This could be much more widely practiced. Fifty per cent of our farmers raise 90 per cent of our food. Their output could be greatly improved by full use of existing agricultural science, not counting on that of the future; and if the remaining majority of farmers were to do no more than follow the example of our better farmers, food production from conventional methods could be raised far above present levels.

All these are important directions in which development plans for increased production could be launched. The danger is that the progress in expanding food production, and the distribution of agricultural products, may be too slow at some one time to avoid widespread want. Many feel that the answer is to be found in a better use of greater amounts of the vast food energy supply we have at present. Large quantities of food materials are discarded as waste because they are not in a form suitable for human consumption. Concentrated effort on wisely utilizing our present available food energy could prove a more rapid method of solving the problem than long-term developments to utilize our natural energy resources.

It is not enough, however, simply to increase the amount of food we grow; it is necessary to supply the proper types of foods. In addition to raising the caloric intake of undernourished people by supplying them with more cereal grains, potatoes, rice, or similar foods, it is necessary that they have the essential elements of a good diet, including minerals, vitamins, and proteins. Our present conventional method of converting carbohydrates and nitrogen to protein is not an efficient process. The animals we use for producing proteins convert only 10–25 per cent of their feed into human food. A supplementary process having greater efficiency, and using surplus foods or materials not suitable even for animal feed, could augment our supply of proteins immensely.

Several processes have been developed to date which through the medium of fermentation transform nutritionally valueless substances into high-protein foods. These processes have utilized fungi as the converting organism. Proteins produced by fungi offer highly important possibilities. The distribution of the essential amino acids in vegetable protein leaves much to be desired, but the proteins in fungi are surprisingly similar to those of meat, and this makes them especially useful as supplements to cereals.

Many fungi can be grown in large masses on cheap carbohydrate material such as molasses, vegetable waste, potatoes, and sulfite waste liquor

from the wood-pulping industry. Other fungi are being used in the beer and whiskey industry; still others have been developed for fat production. It has been estimated that one acre of concrete-enclosed pond used for the propagation of fungi and algae could produce fat equivalent to that yielded by 25 acres of a vegetable oil crop.

Fungi can be produced in quantity within a few hours or days. Their efficiency in protein production from a given quantity of carbohydrates is about 65 per cent in comparison with about 20 per cent for pork, 15 per cent for milk, 5 per cent for poultry, and 4 per cent for beef. The produce of an acre of land can be transformed into ten times as much industrial fungus protein as meat protein.

The idea of fermenting industrial and agricultural wastes of all kinds is not new. Work has been done on the production of alcohol from nearly every waste carbohydrate product that occurs in quantity large enough to make its utilization attractive. A partial list of the materials that have been used in this manner would include lumber waste, cannery and dairy by-products, pulp mill waste, starchy grains, straw, by-products of the sugar industry, brewery waste, waste liquor of the clothing industry, and grain hulls.

Each of the above categories could be broken down further. The general idea is that any waste which contains carbohydrates in concentrations of 3 per cent or more can be fermented economically, barring the presence of toxic material. Work is now in progress on the microbiological destruction of phenolic compounds in industrial wastes, which may open up other sources of fermentable carbohydrates. Considerable research has been done by the wood industry in the United States on the growth of fungi. They have concentrated on using only wood waste, and the fungus proteins obtained were used for animal feed. Many ask, therefore, "Why could not a process be developed that would make the production of good high-protein food for human consumption economically feasible from waste products?"

Such a process has been tried, utilizing yeast as the fungus. The British recognized the need for protein supplements to the diet of the people of Jamaica. This region has a plentiful supply of carbohydrates, but an insufficient supply of proteins. The British instigated the production of food yeast (*Torulopsis utilis*) for the purpose of increasing the protein available for human consumption. In this process, blackstrap molasses was fermented with *T. utilis,* and the yeast was recovered as a dried flake product. Data and final conclusions are not available.

Wood waste and other waste vegetation represent the world's greatest untapped resource of organic material. From wood waste can be obtained sugars which may be used as substrates for fermentation or the growth of fungi. Notable among the industrial processes which have been developed for converting wood waste to sugars are those of Scholler and Bergius. Both these processes produce fermentable sugars from wood chips, making them available for utilization by the yeast *T. utilis.* The efficiency of the Scholler process is said to be 14 kg. yeast obtained per 100 kg. dry wood used. Approximately two thirds of the nitrogen (added as ammonium hydroxide) is recovered as yeast protein. The dried yeast produced by these techniques was too bitter for human consumption, but a yeast extract has been prepared, flavored with onions, celery, parsley, or carrots, and marketed as a paste. Thus formulated, yeast proteins were accepted. The practical use of wood conversion is limited only by the lower cost of competing carbohydrates, and the economics in favor of wood conversion are constantly improving.

Brahmer[1] described a technique for producing *T. utilis* by fermenting pentose sugars in distillation residues. He states that the production of carbamide for use as a nitrogen-rich stock feed is preferable to that of the yeast. Mangold[2] reported that *Torulopsis* yeast flakes contained 24.5 per cent crude protein, which was 70.16 per cent digestible by sheep and 64.5 per cent digestible by swine. It has been stated, however, by Fink (Irex Company, Fulbach, Germany) that an all-yeast protein diet causes damage to the liver in rats because of the low cystine content of *T. utilis* protein.

Industrial processes have tried utilizing fungi other than yeast. Waste sulfide liquor has been fermented by *Oidium lactis,* a mold. The dried powder obtained from this fermentation was used as a protein supplement in the manufacture of sausages in Germany during the last war. This product, however, lacked certain nutritional qualities, and its manufacture was stopped.

A personal conversation with Professor Lembke, M. D., was recorded by interviewers[3] investigating German industry following World War II, in which he stated that he had used several strains of fungi in human feeding. Food preparations were made by him from strains of *Fusarium, Candida, Oidium, Endomyces,* and *Rhizopus.* Lembke stated that the general health of the people to whom these molds were fed was better than that of the people acting as controls. Professor Lembke suggested that his strain of *Fusarium* was probably the most satisfactory. The East Munich Dairy Station was reported

by him to be growing the *Fusarium* on whey. The strains of *Fusarium* and *Rhizopus* used by Lembke were high in cystine, methionine, and glutathione. As most yeasts are low in the very important nutritional material cystine, it appears that molds would be more satisfactory fungi to use for human food production, provided they are equal to food yeast in other essential respects. The use of molds for this purpose has received only slight consideration, and, to our knowledge, no industrial mycological research has been conducted to investigate this source of food supply. The present knowledge of the protein constituents of mold mycelia is fragmentary and incomplete.

Aspergillus oryzae has been studied by Takata[4] from the standpoint of its utilization as food for humans. The following compounds were reported as being synthesized by this mold: arginine, histidine, lysine, cystine, tyrosine, tryptophane, adenine, hypoxanthine, betaine, and stachydrine. Takata found, however, that, although *A. oryzae* mycelium contained 38 per cent protein (80 per cent digestible) and permitted good growth of albino rats, it was deficient as a sole protein source. He did find that it was high in vitamin B (growth-promoting and antineuritic).

A difficulty in the animal experiments results from the fact that, to cover the protein requirements of the animals, the mold mycelium must make up 50 per cent of the total food consumed. This means that a large quantity of undesirable material must be ingested. When surface-formed mats of *Penicillium notatum* are fed to rats, a severe diarrhea results. It was reported by Lembke, in records of the human feeding experiments performed by him, that these materials caused diarrhea if they were not completely autolyzed by heating. Wooley[5] reported that mycelium of *A. oryzae* was toxic to rats, but the toxicity could be overcome by the addition of other protein complexes to the diet. Mycelia from *A. fischeri, A. oryzae, P. chrysogenum,* and *A. sydowi* were toxic to rats when they comprised 50 per cent of the food consumed. This toxicity was overcome by supplementing the diet with casein or yeast. This may have been an instance of folic acid deficiency, which apparently was not investigated.

A similar instance of the need for supplements to mold protein was reported by C. E. Skinner,[6] who worked with *Penicillium flavo-glaucum, P. roquefortii,* and *Geotrichium lactis.* He concluded that this mold was inadequate because of the low cystine content of the protein.

Vinson[7] found that *Fusarium lini* mycelia supplemented with thiamine were a satisfactory source of protein and vitamins for normal growth, reproduction, and lactation in mice. Vinson[7] also found that *F. graminearum* was satisfactory only if supplemented with multiple B vitamins.

Clutterbuck[8] isolated a protein fraction from *Penicillium notatum* and *P. chrysogenum,* which, upon hydrolysis with enzymes and acids, was found to contain the following compounds: melanin, arginine, histidine, cystine, and lysine.

Gorcica[9] found that the incorporation of 10 per cent *A. sydowi* mycelia in a food ration low in vitamin B complex supported good growth in rats. Enough B_1 was present in food containing 10 per cent *A. sydowi* mycelia to protect chicks against polyneuritis. One per cent mold mycelia counteracted pellagra in chicks on a diet containing little vitamin B_2 (vitamin G). Mold fed at a level of 30 per cent prevented paralysis of chicks on a diet low in vitamin B_4. Three per cent *A. sydowi* was necessary for good growth in chicks.

Although little work has been done on the protein content of mold mycelia, the microbiological production of fat has been extensively investigated in Germany. Lindner[10] and others developed the *Endomyces vernalis* process. These workers studied various organisms, including fungi, yeasts, and bacteria. Fink[11] developed a means of fermenting milk whey with *Oospora lactis.* In this process, the fat content of the dry mycelium approximated 22 per cent, with a fat coefficient (grams of fat produced/grams of carbohydrate utilized) of 12–14/100. With regard to the fat coefficient, it is interesting to note that Rippel[12] calculated the maximum yield of fat to be expected from any organism. This calculation was made on the basis of energy relations. He predicted that no more than 15 grams of fat could be obtained from 100 grams of carbohydrate substrate. This value has been approached, but has not been exceeded to date.

During World War II, a successful submerged-vat process was developed by Damm[13] which gave results superior to the shallow-pan method of Lindner's process. The best results were obtained with a selected strain of *Fusarium* which reaches maximum growth and fat content in 40–48 hours. A great variety of substrates can be used as carbon sources by this organism: glucose, fructose, organic acids, acid amides, disaccharides, and pentoses (utilized more slowly). The *Fusarium* oil is quite similar in analysis to peanut oil and olive oil and is said to be interchangeable with these for human consumption and in industry. Fatty acids of *F. lini* were investigated by Fiore.[14] The following analy-

TABLE 1

FOOD VALUE OF MUSHROOMS

	Percentage Fresh Basis				Carbohydrates		Value per Kg. Dry Weight	
	Moisture	Ash	Protein (N×6.25)	Fats (Ether Ext.)	Crude Fiber	N.F.E.	Calorific	Protein
Agaricus campestris (canned in France)	92.58	1.38	4.63	0.03	0.92	0.46	211	62.40
" " (Philippine var.)	78.30	1.66	10.13	1.37	2.02	6.52	810	46.68
A. merrillii Copel. B.	89.02	1.09	5.36	0.17	0.76	3.60	383	48.85
A. perfuscus Copel.	90.06	1.02	4.71	0.20	1.04	2.43	311	50.10
Auricularia auricula-judae	16.40	7.87	9.69	1.22	5.79	59.03	2931	11.59
Auricularia sp.	89.07	0.51	0.66	0.91	2.16	6.69	386	6.04
Hirneola affinis	98.02	0.22	0.19	.27	0.23	1.07	77	9.60
Collybia albuminosa	89.93	0.79	2.96	.40	0.81	5.11	368	6.28
Auricularia polytricha	90.45	0.57	0.60	.93	1.14	6.31	370	29.44
Collybia sp.	95.18	1.24	0.32	0.20	0.69	2.37	129	6.72
Cortinellus sp. (from China)	19.49	4.87	20.82	2.36	10.89	40.57	2777	27.10
C. shiitake (from Japan)	18.37	5.30	15.29	0.97	12.02	48.05	2687	18.73
Lepiota cepaestipes (poisonous, French)	79.19	2.02	4.81	.60	2.41	10.97	703	23.11
L. chlorospora (" ")	91.32	1.08	4.38	.10	0.79	2.33	284	50.41
Lentinus squarrosulus	70.77	1.56	2.44	.99	6.33	17.91	926	8.75
L. exiles	71.71	1.20	4.52	.60	9.19	12.78	765	15.97
Pleurotus ostreatus	10.65	5.88	12.04	.86	7.44	63.13	3162	13.48
Lentinus sp.	61.88	0.97	1.56	.05	0.86	2.65	154	18.75
Marasmius sp.	9.35	1.55	3.09	.76	1.99	3.26	331	29.06
Lentinus sp.	0.26	1.13	3.57	0.40	3.39	11.25	645	13.09

sis is given: palmitic, 19.8 per cent; linoleic, 32.9 per cent; and oleic, 37.3 per cent.

The study of the total fat produced by filamentous fungi has been limited almost entirely to species of *Penicillium, Aspergillus,* and *Fusarium.*[15] New fatty acids discovered in fungi are spiculosporic acid from *Penicillium spiculosporium*[16] and minioluteic acid from *P. minioluteum.*[17]

There is evidence of great variation of fat production between different strains of any one species. The great majority of genera have been investigated with the production of fat in mind, rather than proteins, as the oil produced for industry was certain of a good market. Much of the current fat production work centers around yeast, *Rhodotorula rubra.*

In compounding a complete protein food, however, some have considered the higher fungi to offer more promise than the molds, although little work has been done on their culture.

TABLE 2

INORGANIC CONSTITUENTS OF MUSHROOMS BASED ON ASH

	Ash-Dry Basis	Percentage of Inorganic Constituents of Ash										
		SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	Na_2O	K_2O	P_2O_5	S	Cl	Total
Collybia albuminosa	7.85	14.34	7.10	0.95	3.86	5.04	9.10	17.33	39.95	1.35	Trace	98.99
Volvaria esculenta	13.20	15.23	4.47	0.99	2.35	0.92	15.37	24.76	30.14	1.42	3.85	99.50
Lycoperdon lilacinum	7.73	5.85	1.50	1.19	1.76	1.61	9.46	29.29	48.01	0.62	Trace	99.28
Cortinellus shiitake	6.05	9.28	5.69	0.71	2.73	6.77	24.04	24.82	19.07	3.91	1.20	98.22
Cortinellus sp. (China)	6.49	15.17	6.07	0.33	3.59	7.05	21.17	27.37	16.41	2.21	Trace	99.37
Lentinus exilis	5.24	11.07	6.44	0.75	3.51	1.89	21.38	29.65	22.45	1.19	"	98.13
Auricularia sp.	4.67	9.04	12.65	2.33	11.05	7.97	6.62	17.77	29.89	2.17	"	99.09
Agaricus campestris (France)	18.60	8.96	7.91	6.22	3.11	0.89	42.58	4.02	8.22	2.08	—	—
Pholiota sp.	12.59	4.01	4.01	9.73	12.42	1.02	23.64	5.44	33.04	2.03	2.74	98.09
Lepiota chlorospora (poisonous)	12.44	3.35	14.88	10.05	4.19	1.52	20.40	6.98	33.19	2.53	1.15	98.24
L. cepaestipes (poisonous)	9.71	0.92	9.61	5.03	0.91	3.14	13.59	27.49	33.19	2.51	—	—
Marasmius (looks like *M. oreades*)	14.55	16.24	7.91	3.71	3.09	1.35	20.30	21.50	22.75	1.95	1.57	100.37
A. campestris (Philippine var.)	9.93	2.52	5.84	1.84	6.14	0.67	33.21	14.62	27.33	1.39	6.45	100.01
Lentinus sp.	5.72	14.41	8.66	13.88	2.11	2.94	6.73	18.33	24.77	1.03	—	—

Adriano[18] analyzed 33 mushrooms commonly used in the Philippine Islands, and his detailed analyses are presented in Tables 1 and 2. The moisture content of the fresh mushrooms analyzed by Adriano is about 90 per cent. The protein content is, on the whole, high enough to compare with most foods. These mushrooms, some of which are regularly imported into the islands from France and China, make up a considerable portion of the Philippine diet. It has been thought that markets could be found for fermentation-produced fungus foods in regions such as this where mushrooms are already established as an important food item, and that these countries could probably establish their own factories and make use of the cheap blackstrap molasses or other carbohydrates they produce.

The percentage of digestibility of *A. campestris* protein as reported by Bohmer,[19] Mornes,[20] Saltet,[21] and Skinner[22] ranges between 64 and 71 per cent. The proteins are reported by Saltet[21] to be 69 per cent digestible by humans. The remaining indigestible N is probably tied up in glucoseamine, chitosan, or chitin.

Human feeding experiments performed by Lintzel[23] show that the proteins of *A. campestris, Cantarellus cibarius, Boletus edulis,* and *Morchella esculenta* are approximately equal to muscle tissue and vegetable protein in nutritional value. Of the total protein nitrogen, 72–83 per cent is digestible. When used as an only source of dietary protein, 100–200 g./day (dry weight) of mushroom tissue maintained the nitrogen balance in subjects weighing 70 kg.

In feeding experiments with *A. campestris,* Quackenbush found that this fungus was a good source of B vitamins, but that it was deficient as a complete dietary protein source. Rettew[24] reports vitamins B, B_2, C, K, niacin, and pantothenic acid in sporophores of *A. campestris,* and Kezeli[25] determined in detail the vitamin C content of various species (Table 3). Scheunert[26] gave the data on vitamin D content of some edible mushrooms (Table 4).

Humfeld and Sugihara[27] have produced *A. campestris* in a deep-vat fermentation. Their yield (wet basis) was 100 g. mycelial product per liter of 5 per cent sugar solution. The analysis of this product is given in Table 5.

The fermentation of *A. campestris* has been carried to the pilot-plant stage by workers in the U. S. Department of Agriculture. Blackstrap molasses was fermented, yielding a mycelial product which tasted much the same as the commercial fruiting body, provided the fermentation was prolonged two days beyond the point of total sugar utilization. If this fermentation was stopped at the time of total sugar utilization, the product was essentially the same nutritionally, but was flavorless.

Since little work has been done on the production of mushrooms other than *A. campestris* in fermentation, many think it would be profitable to explore this field further. Morels, which are attestably superior to the mushroom of commerce, as well as species of *Coprini* and many other common mushrooms, could be investigated. It has been considered that certain members of this group of organisms would surpass *A. campestris* in the fermenting of carbohydrate substrates. The few attempts that have been made to cultivate morels

TABLE 3

VITAMIN C CONTENT OF VARIOUS MUSHROOMS

	Mg. Vitamin C/100 g. (mg. %)					
	Wet Weight			Dry Weight		
	Basic Extract	Acidic Extract	Total	Basic Extract	Acidic Extract	Total
Psalliota sylvatica	49	4	50	480	40	520
Boletus edulis	31	5	36	215	35	250
Bactarius scrobiculatus	15	18	33	145	170	315
Clavaria botrytis	19	3	22	225	35	260
Lactarius piperatus	20	1	21	195	15	225
Hydnum imbricatum	18	1	19	215	10	225
Cantarellus cibarius	18	1	19	234	9	243
Lepiota procera	18	0	18	120	0	120
Pholiota mutabilis	11	2	13	96	18	114
Lycoperdon gemmatum	5	6	11	51	54	105
Amanita muscarina	7	4	11	81	51	132
Russula incarnata	9	1	10	84	9	93
Clytocybe laccata var. *amethystina*	3	2	5	33	15	48
Russula lilacea	4	2	6	33	15	48

TABLE 4

VITAMIN D CONTENT OF VARIOUS MUSHROOMS

Mushroom	International Units per Gram
Boletus edulis	0.83
Cantharellus cibarius	—
Helvella esculenta	1.25
Agaricus campestris	
Grown in dark	0.21
Open meadow	0.63

artificially have met with little success. Many of the edible fungi have strict symbiotic relationships with the roots of particular species of trees and will grow nowhere else. Unfortunately, most of the higher fungi are highly specific in their nutritional requirements, and considerable modifications of the nutrient materials might be necessary before they could be cultivated on carbohydrate wastes.

We must recognize, of course, that there are certain factors other than the technical feasibility which must be considered. Even if it were found practical to supplement the diet with fungus food, this could substitute for only a fraction of conventional proteins and fats. Compared on the same basis, mushrooms contain about one tenth as much protein as meat or fish and about a hundredth as much fat as pork. Obviously, we cannot replace conventional proteins and fats with fungus food completely; the large bulk required would be out of the question, and such large amounts of fungus, even if not toxic, would lead to a very unbalanced diet. In actual practice with food yeast, the amounts consumed are of the order of a few grams per person per day.

The greatest need for added protein and fat or for food generally is in such overpopulated lands as China, Japan, and India, where the diet is limited to certain foodstuffs by religion or compelling tradition. Efforts to improve the diets of such peoples by introduction of novel foods have met with great resistance from the mores of these needy populations. Even in the United States we have had many examples of resistance to new concentrated foods, as in the case of emergency Army rations and dehydrated milk, eggs, and vegetables.

TABLE 5

DATA ON ANALYSIS OF *A. campestris*

	Commercial Fruiting Body	Fermentation-produced Mycelium	
		White Variety	Cream Variety
Protein (N × 6.25)	37.25	35.5	45.3
Fat (ether extract)	1.81	2.3	—
Carbohydrate	38.19	48.8	—
Fiber	10.38	6.92	—
Ca	0.023	0.12	0.106
P	1.42	1.28	1.24
Fe	0.019	Trace	Trace
Ash	12.00	4.59	5.24

If fungus food were necessary and acceptable, we would still have to consider the economics of it. It has been estimated that, with a $1,100,000 plant, costing $930,000 per year to operate, 6000 tons of food yeast could be produced annually at a cost of 7.7 cents per pound. This seems very reasonable compared with beef and butter, but the comparison should be made with rough fish and cheap oils that are staples among the hungriest of the world's people. By this comparison we might find fungus food in an unfavorable competitive position.

All factors considered, however, the possibilities of finding a cheap, suitable, low-cost fungus food are still challenging. There is a reasonable possibility that synthethic photosynthesis may become a reality within the next decade or so, dispensing with the need for any other nonconventional method of amending the food supply. Until this occurs, however, many scientists will consider that the fungi offer good possibilities for a rapid method of increasing our food supply.

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Scientific Method and Social Science—East and West

RUSSELL L. ACKOFF

Russell L. Ackoff took his Ph.D. in the philosophy of science at the University of Pennsylvania, where he was an instructor during 1941–42 and 1946–47. He was an assistant professor in philosophy and mathematics at Wayne University for three years and a survey statistician for the U. S. Bureau of the Census for one year. Since 1951 he has been research associate and professorial lecturer, in the comparatively new field of operations research, at the Case Institute of Technology, Cleveland, Ohio. His article is based on a paper presented in the Symposium on Soviet Science given at the annual meeting of the AAAS in Philadelphia, December 26–31, 1951.

DIALECTICAL and historical materialism, as formulated successively by Marx, Engels, Lenin, and Stalin, is the prevailing philosophy of nature and science in the USSR. No significant changes in, or extensions of, this philosophy have been made in recent years. This assertion is made on the authority of A. Zhdanov, former secretary of the Central Committee of the Communist Party, chairman of the Supreme Soviet of the Russian Soviet Republic, and member of the presidium of the Supreme Soviet of the USSR. No one quotation from his 1947 address to the Party's Central Commitee can show the full intensity of his indictment of Soviet philosophy, but this sample reflects the general tone of his remarks:

> Our philosophers have lagged behind. Apparently they have not taken note of the absence of principle and ideacontent in philosophical work, of the neglect of present day themes, the existence of servility and fawning before bourgeois philosophy. Apparently they believe that a turn on the ideological front does not concern them. It is clear now that the turn is necessary.[1]

Many scholars in our culture have already undertaken an extensive critical evaluation of dialectical and historical materialism. I do not intend to add to this discussion. Instead I should like to consider a facet of science and its methods in the East and West that are frequently overlooked on both sides of the cultural curtain—that is, the social sciences and their methods.

Even a cursory examination of American and Soviet science leaves one with the impression that in both cultures, the social sciences are considerably underdeveloped. A closer examination reveals that political influence on the social sciences is very intense in both cultures and, further, that the free development of these sciences is being suppressed in both cultures. I shall present some evidence in support of these observations, and then I shall show how methodology is involved in this deliberate stunting of the growth of the social sciences. Finally, I would like to offer a possible explanation for this phenomenon and draw a few morals for all of science. This plan, I realize, is grandiose for so short a paper. But, since my objective is to raise questions rather than to settle them, brevity may be an advantage.

First, let us consider the social sciences in the USSR. It should be made clear at the outset that, in the words of the expert on Soviet science, Barrington Moore, "Sociology as such does not exist as a separate discipline in the USSR. Its subject matter is investigated primarily by philosophers and economists."[2] There are no separate departments of sociology in Soviet universities. One sociologist, in a sympathetic presentation of contemporary Soviet sociology, asserts that it "merges with history, economics, law, the work of central statistical offices of the government, the trade unions and the budget and planning authorities."[3] This explains a fact which strikes the American scientist as peculiar when he reads the Soviet scientific literature; the fact is that sociology and social science are virtually never referred to as such by Soviet scientists. For example, Sergei Vavilov, president of the Soviet Academy of Sciences, refers to the sciences as "physics and mathematics, psychology, chemistry, biology, medicine, geology, geography," and "agriculture and the technical sciences."[4]

The names of the eight sections of the Soviet Academy reflect this omission conspicuously. They are: Physics and Mathematics, Chemistry, Geology and Geography, Biology, Technical (applied), History and Philosophy, Economics and Law, Literature and Language.

From such evidence as this it is clear that sociology and other social sciences, with the possible exception of economics, have lower status than the other sciences. This is reflected in the fact that the Stalin prize in science has not been awarded for work in sociology or related fields—at least not in recent years.

These facts do not mean that social inquiry does not take place in the USSR. On the contrary. There is considerable sociological inquiry into the field of propaganda. Barrington Moore points out, however, that

> . . . the occupation of propagandist in the Soviet Union is completely free of the derogatory connotations sometimes associated with propaganda work in the United States. A propagandist is one whose task it is to win public support and understanding for Communist Party policy in the detailed day-to-day work of a collective farm, industrial enterprise, trade union, and among the public at large.[5]

The importance attributed to such work is reflected in an August 1946 report in the Soviet publication *Bolshevik,* to the effect that the Communist Party's Central Committee was dissatisfied with the propagandistic work of the Academy of Sciences of the USSR. Consequently, the Party set up its own new Academy of Social Sciences, with the specific task of training propagandists. This new academy was placed under the direct control of the Party's Department of Propaganda and Agitation. Despite the name of the academy, none of its twelve division titles make reference to sociology or anthropology. It is also interesting to note that this new academy was "purged" by the Party about two years after its founding.

Social scientists, as already indicated, also work in "planning and other agencies of the government that have to carry out a great many statistical operations."[6] There is some work being done in anthropology also, but its emphasis is on the historical rather than on the contemporary.

In fact, the methodology of Soviet social science is all historically oriented. This is, of course, consistent with dialectical and historical materialism. This methodological orientation explains, to a certain extent, the fact that the East does not treat the social sciences as a separate discipline. History, which is an extremely important discipline in Soviet Russia, includes a great deal of what we consider to be social science. The historical approach is pervasive. It yields the analyses of social structure and processes which support the prevailing social theories, themselves a product of philosophical-historical studies. The Russians take the fundamental laws of society to be known and therefore direct most of their social inquiry toward finding either further evidence for, or ramifications of, these laws. For example, one Soviet social philosopher asserted at the 1943 jubilee session of the Academy of Sciences that "to make generalizations about our great epoch and to discover its conformity to scientific laws is a scientific task of great importance. Our epoch has received a general scientific explanation . . . and its laws have been formulated in the works of Joseph Vissarionovich Stalin."[7]

The historicism of Soviet social inquiry is either a product or a producer of another important characteristic of Soviet social science. Relatively few data, in our sense of the term, are available to the Russians. Their governmental fact-finding agencies are fewer in number and are less active than ours. For example, many of the data collected in the USSR census of 1939 have yet to be tabulated, collated, and analyzed. There is no steady stream of social surveys to provide "fresh" data. Social inquiry and governmental planning are conducted with what we would consider to be very sparse information. More data, however, are being made available, for social surveys are becoming increasingly popular in the USSR. There is no indication, however, that the historical approach will be replaced.

The emphasis on history and the de-emphasis on current and fresh data mean that our notion of social research enjoys no prominence in Soviet thought. Furthermore, there is no indication of interest in developing methods for social research under controlled conditions. Social hypotheses are accepted and rejected, not by what we would consider to be critical tests, but by historical analyses. The fact that there is no evidence of attention being given to developing methods of social experimentation is consistent with the belief that the historical method is more than adequate. There appears to be no self-conscious attempt in the USSR to develop or improve the prevalent historical approach to social inquiry. There is no evidence that I can find that the Russians are attempting to develop new or improved criteria for the adequacy of historical analyses. The criterion currently in use is both rationalistic and crudely pragmatic. The results of historical analysis are taken to be true if they agree with the main body of social doctrine and if, when incorporated into a social plan, they

work effectively relative to the Soviet social objectives. But no scientific measures of effectiveness have been or are being developed. In sum, there seems to be no concern in the USSR with developing or improving the prevalent method of social research.

The main characteristics of Soviet social science, then, may be said to be the following: (1) With regard to status, the social sciences are at the bottom of the scientific ladder. (2) With regard to subject matter, these sciences are preoccupied with the investigation and application of propaganda for the sake of promulgating attitudes and information congenial to the political bureaucracy. (3) With regard to method, the social sciences depend mainly on historical analyses and are not dependent on data or experimentation. They show no signs of interest in improving or extending their methods so as to be able to grapple scientifically with fundamental social problems.

How does our own social science compare with the Soviet?

Recognition of the social sciences as a separate discipline in this country is almost complete. But, as in the USSR, these sciences have low status in the scientific community. Our National Academy of Sciences, like the Soviet Academy of Sciences, has no section devoted to the social sciences. In the recent proposal to establish a National Science Foundation many, including scientists, argued against the inclusion of the social sciences. It was argued by scientists and laymen alike that the social sciences are not really "sciences," or at least that they are not "mature" sciences.

In other Western nations, the situation is seldom better, and frequently it is worse. In England, for example, as in Russia, there are few universities with departments of sociology. There, too, history and economics absorb most social inquiry. Nobel prizes have yet to be awarded for work in the social sciences.

With respect to status, then, there is no fundamental difference between Soviet social science and our own.

Let us now consider the subject matter of the social sciences. Our social scientists, like those of the USSR, are preoccupied with problems of propaganda. We do not usually call it that, but predominant in our sociological literature is the study of public opinion, attitudes, beliefs, morale, consumer preferences, mass and bureaucratic communication, and so on. To be sure, other areas are also under investigation (as they are in Russia), but most social inquiry is centered around public and private propaganda. For example, the social scientists whose names are most familiar to the American public are Gallup and Roper. During World War II a staff of sociologists was retained by the Treasury Department to help sell War Bonds and the ideology that goes with them. The State Department retains a staff of opinion analysts that is supposed to keep its fingers on the public pulse. Also during the recent war the Library of Congress set up a section to study propaganda methods. Psychological warfare was institutionalized during the war and continues to flourish. The Army itself used social science analysts to study soldier morale, and to advise on ways and means of improving it. The result of this work was published in the four-volume *Studies in Social Psychology in World War II*,[8] which has been hailed as the most important publication in postwar social science. Of particular importance is the third volume, *Experiments on Mass Communication*. The jacket of this volume asserts that "the primary purpose of the research here reported was to evaluate Army films and programs designed to make the soldier aware of the ideological issues behind the war."

Market research is pervasive in this country, and it is obviously involved in propaganda. Our most successful social research groups are those for opinion and attitude survey. To mention but a few, there are the University of Michigan Survey Research Center, the American Institute of Public Opinion, and the Office of Public Opinion Research. We have two journals devoted exclusively to opinion and attitude studies, and the remainder of the sociological journals devote a large part of their space to these topics. Of the thirty-three publications of the Social Science Research Council in 1948–49, more dealt with public opinion than with any other topic—that is, eleven of the thirty-three. In a recent book entitled *Propaganda, Communication, and Public Opinion*,[9] 2558 articles and books on these subjects are listed.

With regard to subject matter, then, both Soviet and American social scientists are preoccupied with the study of propaganda and the application of the results of these studies to support the policies of those in political and economic power.

Methodologically, the social sciences of East and West are quite different, as I have already indicated. Our dominant method is not historical analysis, but the social survey. We have very little controlled experimentation. Our sociologists are preoccupied with facts rather than with theories. There are relatively few theoreticians, but there are numerous data-gatherers. Our tendencies are microscopic. We know the mean age, the average

number of children, the median number of school years completed, of waitresses, gasoline station attendants, and prostitutes. We have accumulated enough undigested—and undigestible—data to give any science an upset stomach.

Here, as in Soviet Russia, relatively little attention is given to the development of the methodology of the social sciences. This statement will be taken as a blasphemy by many social scientists and philosophers unless (and perhaps even if) I make clear what I mean by the methodology of the social sciences.

I take methodology to have three related functions: (1) to develop more efficient ways of investigating problems already capable of scientific inquiry; (2) to develop means for scientifically investigating problems at present not capable of being investigated scientifically; and (3) to develop criteria by which scientific methods can be evaluated and thereby formulate principles of efficient scientific inquiry.

What have our philosophers of science been doing for the development of our social science methodology? The two dominant schools in the field of the philosophy of science are logical positivism (or logical empiricism) and pragmatism. (The majority of our professional philosophers have no interest in science as such and belong to neither school.) The physical bias of logical positivism is conspicuous even to the casual observer. This school has developed the doctrine of the "hierarchy of the sciences," in which it is asserted that there is a one-directional conceptual dependence of the various scientific disciplines. Physical concepts are taken to be basic and irreducible. On this foundation, the concepts of chemistry, biology, psychology, and the social sciences are taken to be developed in this order.

It is only natural that those who accept this hierarchy should attend to clarifying what they take to be the basic concepts—that is, the physical ones. This follows from their conviction that the derivative concepts cannot be made precise until the basic ones are. Hence it is no surprise to find that practically no logical positivists are attempting to provide the social sciences with a conceptual framework that will enable these sciences to extend their area of effective scientific investigation.

The pragmatists, on the other hand, are preoccupied with the social sciences. John Dewey worked in this area a great deal, and many of his followers have followed suit. But, with the exception of some of Dewey's work and that of one or two others, this preoccupation with the social sciences has not been methodological; it has been philosophical. There is a good deal of difference between a social philosophy and a philosophy of social science. Social philosophy attempts to tackle broad social problems by nonexperimental methods; it combines historical analysis, personal observation, and speculation. The philosophy of social science, on the other hand, does not attempt to answer these problems, but attempts to formulate the conditions under which, and to provide the instruments by which, these problems can be tackled experimentally. The philosophy of social science does not itself try to say what social objectives should be, or how society should be structured; it is concerned with showing how experimental investigation into such problems as these can be conducted.

In sum, no significant contribution to the methodology of the social sciences has been made by philosophy.

In the present, as in the past, some of the most important methodological developments in science have resulted from the active intervention of mathematicians in content-areas of science. The pertinence of this remark with respect to the physical sciences is obvious. It is becoming more and more so in biology. But in sociology I can think of only one mathematician who has intervened in this country. The mathematician's lack of interest in the social sciences is conspicuous, despite the urgent need for his assistance and the ripeness of these sciences for his services. This is true both in the East and in the West.

What of the social scientists themselves? They are considerably more active in methodological matters. But their interest and success have centered in the area of propaganda. Opinion, attitude, and belief scales are being developed at a furious rate. Scaling methods for numerous properties related to propaganda have been constructed. But even the most sophisticated scaling methods, such as those developed by Thurstone, Guttman, and Lazarsfeld, by their authors' own admission, do not identify the variables scaled. Further, they do not provide scales with identifiable and definable units. For this reason I prefer to refer to those developments as ones of technique rather than of method. In general, these developments have enabled our social scientists to gather and tabulate data more efficiently, but have helped little in converting the data into facts, and the facts into laws. Our social sciences, like those of the USSR, are not yet capable of tackling basic and fundamental problems of society with any degree of precision.

nor do they appear inclined to develop in that direction.

Many critics have commented on the triviality of much of our social research. A premium is placed on conformity to mediocre standards set by universities and professional organizations. Deviation from accepted techniques and methods is discouraged. Our institutions have failed to support and encourage the development of new methods in the social sciences. All one need do, for example, is examine the research grants of our many scientific foundations. The impression one would get is dramatically summarized by one of our foremost social scientists, S. A. Stauffer, of Harvard University. I offer a few quotations from one of his recent articles:

> Quick plausible "answers" in sociology and social psychology are rewarded in our culture: tedious modest experimental design is not in demand, and hence our discipline is not accumulative.
>
> In a society which rewards quick and confident answers and does not worry about how the answers are arrived at, the social scientist is hardly to be blamed if he conforms to the norms. Hence, much social science is merely rather dull and obscure journalism: a few data and a lot of interpretation.
>
> Only a few hundred research studies are reported annually in sociology . . . as compared with more than 20,000 studies summarized annually in *Biological Abstracts*.[10]

All this despite the fact that more than 500 advanced degrees in sociology are being conferred annually!

Let me resort to a few statistics at this point. From 1938 to 1948 the estimated total national budget for social science increased from 34 million to 88 million dollars—that is, by a factor of 2.6. During the same period the corresponding budget for the natural sciences increased from 234 million to 1.25 billion dollars—that is, by a factor of 5.3—and hence more than twice as much as the social science budget. Even more striking is the following: in 1938, 31 per cent of the government's research budget went into the social sciences; in 1948 only 6 per cent was allocated to these sciences. Despite the fact, then, that there are approximately "4 times as many qualified natural scientists as social scientists . . . on the average each of the former receives about 4 times as much for research."[11]

Some might attempt to refute the significance of these statistics as follows: "The investor in research gets more for his dollar invested in the natural sciences than in the social sciences. Why should he invest in the social sciences?" Even if we grant the truth of this assertion, it is not pertinent. We invest primarily on the basis of what we take our needs to be. Cancer research is a case in point. I think an argument could be made for the "poor return" on funds invested in finding a cure for this disease. But we consider the need for a cure and preventive to be urgent. Urgency, not economy, is the key. In both the USSR and the USA, lack of investment in the social sciences indicates that we do not consider social diseases to be critical. We are willing to live with the race-prejudce cancer, the malignant-slum cancer, the war cancer, and many others. It has become a platitude to say that we will not wage peace as hard as we will wage war.

I believe that a more complete explanation of the suppression of the social sciences is possible. Before offering it, I should like to remind the reader that my interest is in arousing concern over the problem, and not in providing a final answer.

Underlying the political management of the USSR and the USA, or any other nation, is a set of assumptions concerning individual and collective objectives and ways of obtaining them. I do not refer to the principles that are preached, but to the principles that are practiced. These principles differ from nation to nation. Whatever they are, they form the basis for governmental action which is taken to be efficient for the objectives of those who benefit most from the respective politico-economic systems. It is of no importance to this argument to identify those who benefit most in each country; it is only of importance to assert that such exist in each nation.

Next, those who benefit most either directly or indirectly exert control over the political and economic course of their respective nations. The continuation of such control and the accompanying benefits to them depend on at least the following: (1) that the basic principles underlying their political-economic system do not undergo any fundamental change; and (2) that the majority of their countrymen do not actively oppose these principles.

I think it is clear that the development of the social sciences would threaten the security of the basic assumptions and those who benefit most from their social acceptance. If we consider the social sciences in the USSR and the USA in this light, I think we can understand their suppression and the restriction of their use to the support of the basic principles.

We have already considered the emphasis on the study of propaganda in both cultures. Developments in this area have enabled governmental

agencies and private businesses (where they exist) to determine what their consumers *prefer*. The notion of preference is important, for the psychologists and sociologists agree that there is a fundamental difference between what a person prefers or *thinks* he wants and what he *really* wants. Opinion and attitude surveys deal with what people think they want. People are subject to considerable influence in their preferences. Here propaganda is a powerful weapon; it can make masses think they want almost anything. Hence, it is particularly significant that there is practically no work being done toward developing methods of determining what people really want, and of making them conscious of these underlying interests.

I have been asserting that Soviet and American social sciences have been forced, or at least induced, to play a politically conservative role relative to their respective cultures. Their main social function is to justify the *quo* which has *status* in both cultures. The Russians overtly demand subservience to governmental policy. We are not so direct, but our methods yield equivalent results. I could refer to numerous university and government incidents, but instead let me refer briefly to a few conclusions reached by the sociologist C. Wright Mills in his research into "The Professional Ideology of Social Pathologists."

Mills observes that there is strong evidence among social pathologists of the preference of slow to fast change.

> The slow "evolutionary" pace of change is taken explicitly as normal and organized, whereas "discontinuity" is taken as problematic. [The social pathologists, he asserts], do not typically consider whether or not certain groups or individuals caught in economically underprivileged situations can possibly obtain the current goals without drastic shifts in the basic institutions which channel and promote them.
>
> The ideally adjusted man of the social pathologist is "socialized." This term seems to operate ethically as the opposite of "selfish"; it implies that the adjusted man conforms to middle-class morality and motives and "participates" in the gradual progress of respectable institutions.[12]

Though Soviet and American ideals differ, both support the principles of progress verbally; verbally, but not in practice. As partial evidence thereof I have submitted the social sciences. I do not know what chance there is of improvement of this situation in the USSR. There are many discouraging signs, but there are also a few hopeful ones. For example, according to a September 1946 issue of *Pravda*, the Party's Central Committee complained that at the University of Moscow with over 2000 faculty, including 83 Stalin prize winners, only five persons joined the Party in that year.

As for our own country, few of us believe that our science is completely free. Many of us believe greater freedom and support of science are urgently necessary. A good place to start is in the social sciences. To have a free science we must have a free society, and we cannot have and maintain a free society without a science that is capable of evaluating that society objectively. I feel, then, that it is the responsibility of all citizens of science to exert every possible pressure toward the creation of a social science that is capable of evaluating society scientifically.

I should like to add a few remarks as a sort of epilogue. I have tried to show some basic similarities between Soviet and American social science. I do not deny the existence of differences, but many of our scientists, philosophers, and politicians have been repeatedly enumerating these differences. The net effect has been a gigantic pat on our own backs, the production of a state of self-satisfaction, and the continued suppression of the social sciences. The emphasis on basic similarities, on the other hand, is designed to produce the opposite effect: aggressive redirection of the social sciences. Through such an effort, I believe, we can not only move toward an improved social science, but also toward an improved society.

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The Messiah in Indonesia and Melanesia

JUSTUS M. VAN DER KROEF

Dr. van der Kroef was born in Indonesia and spent his early years there, but took his Ph.D. at Columbia University. He is the author of various books and articles on the history and social institutions of Indonesia and in 1947 and 1951 spent considerable time in that area, including New Guinea. During the war he served with the Netherlands government and at present he is on the staff of the Department of the History of Civilization at Michigan State College.

ONE of the more noteworthy aspects of the social and cultural patterns of the divers peoples of the Southern Pacific islands is the unique element of Messianism. From the mainland of Southeast Asia eastward to the New Hebrides many cultural traditions appear to revolve around a cataclysmic view of history, a day of reckoning and a millennium, in which the community, led by some savior, or supplied with unbounded material wealth, will be able to overthrow the shackles of foreign control and reach a state of blessedness on earth. The importance of these Messianic traditions for the development of nationalism and contemporary Communism in continental Southeast Asia and adjacent islands is tremendous. In the case of Indonesia, for example, a country which only recently won its independence, Messianic traditions played a role in the development of nationalistic fervor as it was projected against Dutch overlordship. In Melanesia, a region still under the dominance of the various metropolitan powers, such traditions have also been considered as precursory manifestations of a new and unsettling spirit of nationalism.

In Java, Messianic traditions appear to have been influenced by the Hindu concept of the four periods of world history, in which the oldest and most nearly perfect, the "Golden Age" of antiquity, gradually has disintegrated but will be re-established after a period of chaos, and by the Islamic *mahdi* ("Messiah") expectation. Among the oldest Messianic prophecies in Java are those attributed to Jayabhaya, ruler of the East Javanese kingdom of Kadiri (1130–60), although little evidence exists that the prophecies connected with this name are actually his. According to Jayabhaya, Java—or perhaps all of Indonesia—would be free after a period of domination by a "yellow" race. The length of corn and rice stalks would signify a coming liberation from foreign rule, and Indonesia would re-enter the lost "Golden Age."[1] During the Japanese occupation of Indonesia in the second world war such prophecies had an immense popularity and led to a confident expectation in many circles of complete independence after the Japanese regime had ended. In the period of Dutch colonial control the *ratu adil* idea gained ground. *Ratu adil* was generally understood to be some benevolent and just ruler—possibly reflecting a Christian influence—who would end the present hard times and restore the greatness and tranquillity of the past. Throughout colonial history a number of demagogues appearing as the *ratu adil* kept the countryside aroused from time to time.[2] In the nineteenth century, especially, Muslim Messianism appears to have been prominent in Java. The influx of a number of Muslim mystics from the Near East and India, the Islamic *réveil* caused by the Java War (1825–30), and the activities of Diponegoro seem to have made the times ripe for political agitation of a mystic-religious cast. Notable examples are such mystics as Kjai Hasan Maulani, who was exiled from Java by the Dutch in 1842 after having kept Western Java in unrest with his Messianic prophecies of an impending cataclysm and a "liberation" of all the faithful from infidel rule, and Mas Malangjoeda, who met a similar fate because of his incendiary prophecies in 1887.[3] Messianic prophecies also appear to have emanated from Prince Diponegoro, the leader of the Javanese rebellion against the Dutch known as the Java War. Diponegoro believed it to be his

mission to cleanse the island from all foreign contamination and to restore the religious and moral purity that had characterized ancient Javanese civilization. The immense veneration among contemporary Indonesian nationalists for Diponegoro, and his designation as "Prince Liberator" and "Hero of Freedom," indicate the great popularity of these Messianic traditions in Java today.[4]

In the present century Islamic Messianism has manifested itself in such groups as the Hizbul Waton and the Sabillera, Muslim fanatics led by mosque officials, mystics, or fanatics, who made common cause with the disorganized units of the Indonesian Republican Army in its struggle against the Dutch. A near-berserker fury was unleashed by these bands against European and Chinese minorities, who were regarded as the fitting objects of the *perang sabil* ("holy war"). In numerous massacres, especially in Malang (East Java), circumcision was practiced on the Chinese and European victims before they were killed. Islamic Messianism has continued until very recent times. For example, for the past three years the government of the Indonesian Republic has struggled to subdue the Da'rul Islam movement in West Java, which seeks to establish the long-heralded Islamic theocracy along the lines suggested by numerous *mahdis* in Indonesia in bygone years.

As is also evident from the so-called cargo cults in Melanesia, the Messianic element appears to flourish in those areas where a relatively secluded and homogeneous population is suddenly subjected to an incisive process of culture change, enforced from without. An example is the "Samin movement" in Java before, during, and after the period of the first world war. This was an era of a growing administrative supervision and centralization of the government on all political and social levels, even the remotest villages. Tax assessors, agricultural agents, and a host of other public servants descended upon the village society, which was thus drawn almost perforce within a Western orbit. In a small village in Eastern Java there lived around 1920 a simple pious peasant, Samin by name, who because of his austere life and devotional habits was regarded as a saint by his fellows. Samin had a small number of pupils, to whom he confided a simple, pacifistic, and fatalistic philosophy of life, which stressed complete submission to the order of the cosmos. With the advent of the government's administrative and technical reforms in Samin's village, his outlook began to change. Resentment in the community over the forceful alteration of customs and traditions made Samin a champion of the village folk, who opposed further Dutch innovations. Into Samin's preaching crept a note of prophetic warning that a day of reckoning was at hand, in which the white man would be overthrown, and a new golden age of peace and tranquillity would come into being. The Samin movement spread into neighboring districts, and Communist agitators were quick to seize the opportunity to utilize the popular discontent for their own objectives.[5] With the capture and deportation of Samin and the influx of more cautious civil administrators, the movement collapsed. But in other areas of Java, notably in Bantam, Indonesian resentment toward Dutch administrative reforms led to similar outbreaks.

Messianic concepts and traditions have been noted on other islands of Indonesia. On Borneo the *njuli* movement, and in the Minehassa region of Celebes the *mejapi* movement, are cases in point. In the former the expectation is more nearly apocalyptic; the end of the world is believed to be at hand, and afterwards there is to be a "new deal," a new era of equality and prosperity for all the living.[6] The *mejapi* movement may have been influenced by Christian traditions of Jesus as the Savior; the religious element is much stronger here than in the *njuli* movement, and at the same time it is more active politically.[7] The same is perhaps true of the *parhu damdam* movement among the Bataks of Sumatra.[8] Both the *mejapi* and the *parhu damdam* movements are concerned with the preparation for a millennium by some savior or liberator, whose ancestry is linked with traditional deities, and whose love for an especially "chosen people" is woven into folkways and legend.

Messianic traditions in Indonesia are extremely diverse, but those that have been studied in Melanesia appear to be rather uniform in pattern. It is in this area that the popular desire to reach a status equal to that of the European or to enjoy the European's material achievements has given birth to so-called cargo cults, most of them movements of very recent origin. The central theme is that someday the ancestors of the community will bring in a "cargo" on a ship, and that this cargo will contain the goods or techniques that will give the community equal standing with the Europeans. In some areas it is believed that these ancestors will be white, like the Europeans, so that there is a suggestion of a priori genealogical equality. Probably one of the first occurrences of such a cargo cult was the one noted by F. E. Williams in the Gulf Division of Papua in New Guinea. The chief fea-

tures of this "Vailala madness" were the expectation of a cargo, in a ship manned by white ancestors, communal meals in honor of the dead, and divination rites and trances.[9] In subsequent years similar expectations and practices began to be prevalent in northern New Guinea, in which a Messianic element forecasting a cataclysmic change in the subordinate status of the community to the white man predominated. Hanneman has noted how, immediately after the end of the second world war, the departure of the American military caused some native communities to re-create forcibly the setting of the advanced technology and the material goods with which they had come in contact during the war.[10] Communities were organized in camps along the model of military barracks, discipline was imposed, teaching of English and of sexual continence was encouraged, and at the same time the villagers destroyed their gardens, food reserves, and killed their livestock in the hope of thus hastening the day of the coming of the new cargo, which would contain the material bountifulness that would at last strike a balance between the old and the new.

The departure of the Allied forces from Malaita Island in the Solomons similarly gave birth to a cargo cult, called *Masinga* ("fraternity") rule.[11] Here the myth of the coming of the cargo was combined with demands for political self-determination, for education, and for higher wages. Military drill and the exacting of "voluntary" gifts of money from the inhabitants became the chief activities of those who participated in the *Masinga* movement. Despite arrests of the ringleaders and stringent measures against extortion, the cult continues; the expectation that native society will attain all the material benefits that characterize the Western world, and in particular such countries as the United States, seems too strong to be stamped out overnight. What is perhaps even more important is that the United States appears in some cults as the land of origin of the expected cargo, and that the ancestors of the aborigines who will bring the cargo are themselves Americans! An example of such a cult is the "John Frum" movement in Tanna in the southern New Hebrides, which began in 1940–41.[12] The god Karaperamum, believed to be the single ancestor of all inhabitants of the island, and master of its highest mountain, was expected to reappear shortly in the form of the "King of America, John Frum." At first John Frum spoke directly to his people but later sent his orders through messengers. The Christian movement sank into disrepute; the people left churches and missions and went to live in small units in relative isolation in some of the more deserted sections of the island. Traditional practices, such as dances and the drinking of alcohol, which had been forbidden by some missionaries, were revived. A new currency, which had a coconut stamped on it, came into use. All the white man's money was spent, or sometimes even thrown into the sea, the theory being that when all the money was gone, the white traders could no longer make a living and would leave, thus hastening the coming of John Frum. The "King of America" would bring bountiful blessings to all, particularly the material goods in use among the Westerners. Some natives took to wearing imitation wrist watches made of bamboo, constantly shouting "the time" to their fellow-villagers. A number of John Frum's "messengers" have been arrested, among them one who had gone so far as to demand labor for the construction of an airport where American planes could land. Although missionary activity has been resumed, dancing and immoderate consumption of *kava* (an alcoholic beverage) go on as before. The John Frum movement has spilled over to other, neighboring islands. On the extreme north of Malekula, a cargo cult began in which one of the leaders indicated that a U. S. Army captain by the name of W. Otto had promised to send the "cargo" direct from America.

The ramifications of the cargo cult can be very wide. Propaganda on behalf of the organization of a native cooperative can be made in terms of an announcement of a future millennium.[13] This occurred, for example, on Malekula when efforts were made to improve copra production through a cooperative movement, which also had as its objective the amelioration of the living standard of the community as a whole. Communist activity may be allied to a cargo cult. This occurred on Lifu, one of the Loyalty Islands, where money was collected for a ship, whose cargo—or so it was believed—would be made up of the material goods assembled by the Communist Party of France. The cargo cult here involved not only the expected material blessing and the hope of a coming millennium of freedom but also widespread Communist-inspired popular agitation for political liberty, which caused considerable concern among the authorities. Again, in some areas, the religious element seems to predominate in the cargo cult, and a factor of religious syncretism provides a new "mythical justification for the general wish to get rid of the white men and at the same time acquire their riches." An early example of the religious character of Messianism in Melanesia is the Tuka cult of Fiji, flourishing

in the latter half of the last century. According to the followers of the Tuka, a prophet called Nava savaka dua ("he who speaks once") would arise, reverse the existing social and racial values, and make of the Christian God a lesser deity, subordinate to the local traditional gods. This cult seemed to have replaced the even older prophecy of the serpent god Ngendrei, who would one day return and restore the glory of his people over the whites.[14] Elsewhere on Fiji, the tradition of the coming of a new and just king, apparently similar in function to the Javanese *ratu adil,* has recently gained new popularity, particularly with the sullen, though sporadic, resistance against the further inroads of Christian missionary activity that has characterized the islands of late. The new king is said to be a repository of traditional priestly power, and his religious might is expected to be so strong that all foreign gods will have to make way for him. Taking the religious characteristics as a focal point, it would appear that in this respect, too, the Melanesian exhibits a desire to "get even" with the Westerner.

It is difficult to pronounce any general conclusions as to the various Messiahs and their respective movements, because of the immense diversity of cultural and social backgrounds against which they have arisen. From an anthropological point of view, however, it may be said that these apocalyptic tendencies are expressions of an incisive process of culture change, of a lack of balance in traditional society and of a gradual collapse of most cohesive elements of social organization. The projection of an element of cultural equality expressed primarily through material means or through some "white" racial strain parallels similar developments in other areas of the world that have come increasingly in contact with the West, notably Africa and the interior of Australia. The white skin color is traditionally a symbol of aristocratic family origin; among the Javanese kings and nobility a white or pale olive color supposedly denotes divine kinship. The significant role of the ancestors in the cargo cults and in some Messianic traditions in Indonesia is not accidental. The original humans who founded a given community were reputedly closest to the precepts of the divinely guided cosmos and social order;[15] later generations of men are believed to have corrupted these precepts, and only a physical return of the founding ancestors can therefore bring the peace and prosperity of the old, lost, "Golden Age." It is possible that for this reason, in Indonesia as well as in Melanesia, the worship of the dead is one of the last remaining strongholds of traditional culture, and even in those areas where Christianity and Western civilization appear to have made the greatest gains, ancestor worship and veneration for the dead continue.[16] During severe illness dead ancestors are supplicated to restore health; in communal meals the dead are still remembered. As Jean Guiart recently reported for New Caledonia: "I know a Catholic missionary, who, having permitted his flock to hold a recapitulative funeral feast in the traditional way, was worried to find small heaps of diminutive yams, which nobody seemed to care to take, and the presence of which nobody seemed willing to explain."[17]

Finally, two other features of the Messianic cults may be noted: one that I would like to call their "positivistic" aspect, the other their "nihilistic" aspect. As has been noted for Southeast Asia in another connection, a significant feature of the outlook of many intellectuals in this area is their desire to adopt or emulate the technical or scientific achievements of the West without making a commensurate effort to analyze or to understand adequately those culture traits in Western life that have made the technology possible.[18] Despite the desire to emulate the Westerner and his ways, many retain an inner seclusion, a cultural isolation, and appear to be willing only to adopt the outward phenomena or the scientific and technical achievements whereby the West has manifested itself to them. In Melanesia, and in the present state of development of Melanesian nationalism, of which the cargo cult is undoubtedly an important precursor, this tendency seems best illustrated by the very concept of the cargo itself, a concrete, almost "packaged," entity, representing techniques and material goods, which can somehow be acquired, applied, and reproduced without any understanding of the culture or even of the mechanical processes that underlie them. Rather, incipient nationalism in the cargo cults seems to be averse to the traditions of the Westerner, apart from his scientific achievements. The old gods and the old folkways reappear, in slightly modern dress, but little if any identification with Western culture traits appears to exist, even among those who have for reasons of expediency "adopted" Western manners.

The "nihilistic" aspect of the cargo cult and of Messianic movements in Indonesia seems apparent from the wanton destruction of food, livestock, and implements, from enforced sexual continence, and from the practice of abortion and infanticide. It is as if one wished to wipe the slate entirely clean, so that the coming of the cargo, the millennium,

the literal "fresh start," will be hastened. Action for action's sake, discipline, even military drill, become characteristic features of this peculiar nihilistic tendency. One thinks in this connection of the sheer nihilistic spirit that motivated the guerrilla bands in the Indonesian revolution, their myth of invincibility, their belief in some talisman or other magical object, said to give them complete mastery over their enemies. One remembers the apparently senseless destruction perpetrated by these bands, perhaps motivated by the all-pervading Messianic urge that the day of reckoning was at last at hand, that a new beginning for all was now being made. This nihilistic character in association with certain Messanic traditions has earlier been noted in Indonesia in another connection.[19] One is struck by similar features in the prenationalist cargo cults of Melanesia. Whether this nihilism is similar in both cases cannot of course be definitely ascertained, but the appearance of the phenomenon is worthy of some notice

To the social scientist, both Indonesia and Melanesia offer the unusual opportunity of attempting to further analyze and possibly to channel these Messianic traditions and expectations along constructive lines and of bringing them into some semblance of harmony with the new culture traits of the changing societies in the Pacific area.

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WORLD BEYOND SEEMING

How can we see, except through our own eyes?
A rose, a leaf, a grass, a thousand such
Appear before us, scaled to our own size,
Curve to our hand, and warm beneath our touch.
Yet these are landmarks whose familiar shape
Can guide us only in the world we know:
The Here and Now from which we must escape,
The brief horizons past which we must go.

Go where? Into a world beyond all seeming,
Where time does not exist, where even space,
Dimensionless, defies our wildest dreaming,
The universe expanding in our face,
Till we are lost, but in that losing find
A world more trenchant than we left behind.

Mae Winkler Goodman

Cleveland, Ohio

Theory and Practice in Stream Pollution Control*

RICHARD D. HOAK

Dr. Hoak, an authority on industrial waste treatment, spent pickle liquor, and the recovery of manganese from low-grade ores, has been with the Mellon Institute of Industrial Research since 1940. Born in Lancaster, Pennsylvania, he took his Ph.D. in chemical engineering at the University of Pittsburgh in 1948, after earlier work at MIT. During 1929–30 Dr. Hoak was assistant director of the School of Engineering at MIT's Buffalo station. Prior to joining Mellon Institute, he served as district engineer of the Pennsylvania State Department of Health. In addition to his work at Mellon, he is a member of the editorial staff of Chemical and Engineering News, *official publication of the American Chemical Society.*

EVERY good citizen favors sound measures for abating stream pollution. The visual effects of uncontrolled discharge of sewage and industrial wastes cannot be avoided by the observant, and certain less obvious results of pollution are fairly easy to recognize. Actually, relatively few persons have seen streams of any size that were completely free of man-made pollution. But, although the desirability and necessity of pollution control are widely accepted, agreement on the methods and extent of control is considerably less universal.

There are two principal reasons for the difficulty often experienced in gaining full agreement on pollution control measures. The first, and more important, is our meager knowledge of the specific effects of most pollutants on stream ecology and water usage. It is true that scientific research is steadily yielding detailed information on many aspects of the problem, but its fundamental complexity, and the enormous variability of conditions encountered, combine to prevent rapid progress. Organized attack on the broad questions involved in pollution control has been relatively recent, and new problems arise almost as rapidly as old ones are solved. The second difficulty is the large part usually played by subjective judgment in deciding on control methods.

Expert and layman alike are swayed by personal bias and interest in judging the merits of cases where factual data are lacking or unobtainable. Determining the relative importance of aesthetic and recreational values as contrasted with local economic considerations is especially difficult, but frequently necessary. There is no evidence that rational means for solving such dilemmas will ever be wholly satisfactory, because the questions are societal rather than technical. Unfortunately, pollution usually affects downstream neighbors more seriously than those responsible for it, and this factor has sometimes influenced regulatory measures.

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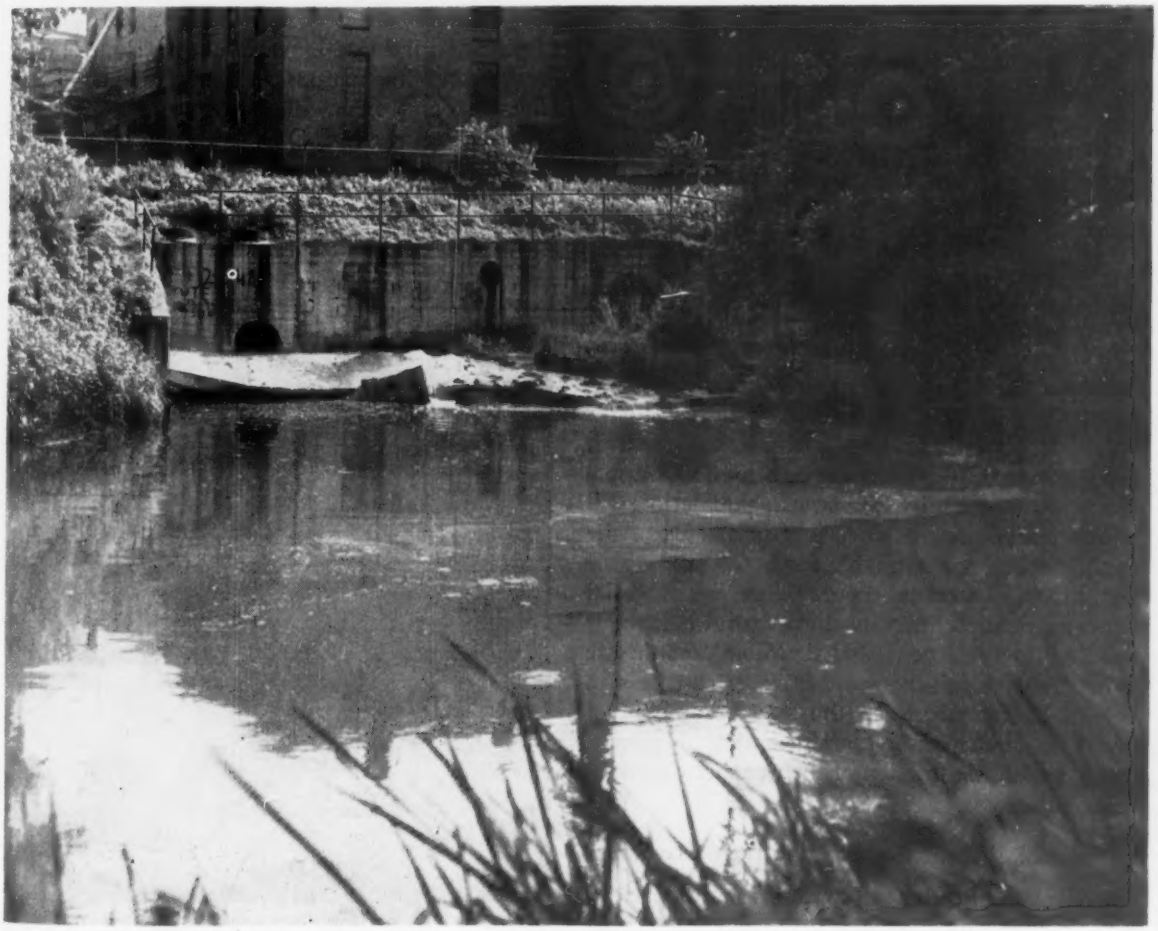
Pollution Control Objectives

It sometimes seems that so much emphasis is placed on the necessity for waste treatment that the object of the treatment is forgotten. Streams comprise a highly important natural resource, and one of their most essential functions is to carry away and assimilate the water-borne wastes of mankind. But streams serve many human needs, and their use for waste disposal should not interfere with their other functions. Unfortunately, there are many instances where such a heavy load of pollution is carried by streams that their value for other uses is impaired or destroyed. The paramount objective of all pollution control measures should therefore be to maintain those stream conditions that will best serve the over-all interests of particular localities. It is economically unrealistic to expect streams in highly industrialized areas to be in as good condition as those flowing through agricultural or forest lands. On the other hand, gross pollution is an of-

fense to human decency, and such conditions should be corrected by appropriate controls.

Establishment of water quality criteria best suited to the needs of any region is not a simple task. It is never easy to please all the people, because of the inevitable conflict between desires and possibilities, and the inadequate public understanding of the complex technical and economic problems involved. Competent engineers with experience in this field know how to collect the data needed to make sound recommendations. Their decisions will include public health, economic, recreational, and aesthetic considerations. They will suggest the kind and degree of waste treatment required to maintain the stream conditions their studies have shown to be desirable. But their findings probably will not satisfy all the local people. Some will not be pleased by the predicted degree of improvement; some will quarrel with specific proposals; other will complain that the cost is too high. These factors are not insignificant, because they have often had their effect in modifying careful engineering conclusions.

Development of criteria of desirable water quality should be undertaken only by those experts in stream sanitation who also know how to reconcile economic questions and to place a reasonable value on intangibles. Intangible values, however, should never be a primary factor in evaluating the economics of a stream improvement program; they should instead be regarded as an extra benefit afforded by meeting other, more essential requirements. The cost of building and operating waste treatment facilities of every description has increased greatly over the past decade, and the public, as well as some engineers, does not always seem to understand that the cost of treating wastes, whether industrial or municipal, always falls upon the taxpayer. For this reason, it has become increasingly important to recognize that streams constitute a basic part of every waste treatment plant. The problem of the engineer



Scum on water is from factory wastes discharged from old canal into a river.

is to recommend that degree of waste treatment which will utilize the self-purification capacity of the receiving water to the fullest practical extent consistent with optimum local conditions.

Self-Purification of Streams

Flowing water has always had a curious fascination for mankind. Troubled spirits are calmed as we gaze at a meandering stream or watch the tumble of water in a rocky chasm. When we contemplate the soothing play of water we do not often think about the complex phenomena that are constantly taking place in it. But most streams contain a great variety of living things which depend on water to supply their food and other needs. Microscopic plants and animals feed upon the dissolved and suspended matter in stream water, and in turn become food for larger species. A complex cycle of life and death goes on continuously in streams, and variations in the cycle are dependent upon the supply of available food.

The kinds of aquatic life in streams vary widely with their natural environments. Streams rising in the granite formations of New England support different species from those originating in the swamps of the Southeast or in the Great Plains; and some streams that have been untouched by human agencies contain a very scanty variety of life forms.

The aquatic life in a stream maintains a natural balance with its environment. As food material increases in quantity or complexity, the number and variety of microorganisms increase rapidly to consume it. This, in turn, multiplies the food supply of the larger animals. If the available food remains at a fairly high level, a great variety of aquatic forms will continue to exist in balance with one another. On the other hand, if the food supply diminishes in quantity, the stream population will decline until a new balance is struck between the organisms and the available food.

Pollution of streams occurs when any material is present in such quantity that natural balance is disturbed to the extent that desirable aquatic life is destroyed or driven away. Streams can be said to be polluted only when the kind or amount of substances discharged to them is continually greater than a reasonable fraction of their capacity for self-purification.

Relation of Pollution Load to Stream Resources

Natural purification of streams is affected to a variable extent by a number of factors, but availability of dissolved oxygen is by far the most important in practically every case. In theory, it should be a relatively simple matter to relate the aggregate biochemical oxygen demand (B.O.D.) of the daily pollution load to the oxygen resources of a stream, but in practice the problem is quite complicated.

Practical application of the familiar Streeter-Phelps[1] formulas describing the rates of deoxygenation and reaeration is limited by the variability of the so-called constants k_1 and k_2. A number of investigators[2-9] have proposed simplified procedures for solving the equations and evaluating the constants. These methods should lead to wider application of established techniques for determining self-purification capacity.

Velz has made important contributions on the statistical analysis[10] of stream conditions in their relation to the capacity of streams to assimilate wastes. He has listed[11] the following stream liabilities: characteristics, quantity, and fluctuation of the pollution load; rate of oxidation at various temperatures; effects of immediate demand or lagging demand; effect of changes in time of passage of pollution induced by variations in channel cross section and fluctuations in runoff, including the effect of dams on low-flow augmentation; extraction and storage of B.O.D. by biological growths; and sludge deposits. The assets available to balance these liabilities are the dissolved oxygen in the

Taking a water sample from an abandoned coal mine that has been sealed.

stream, and that contributed by runoff, tributaries, and reaeration. He stresses the danger of generalizing about self-purification capacity without giving proper weight to such factors as sludge deposits and drought probability. In another paper[12] he describes a statistical method for pollution control that permits optimum utilization of stream capacity.

It is apparent that optimum use of stream resources will not result unless stream capacity has been determined by a comprehensive survey. Such a survey will suggest the most economically sound drought frequency interval upon which to base waste treatment requirements. Comprehensive stream surveys, though rather costly, represent the best approach to rational selection of water quality criteria, and they will be used increasingly as treatment costs continue to mount. It cannot be emphasized too strongly that stream resources should be utilized fully to the extent that unsatisfactory conditions will not occur oftener than once in five to ten years. To require a higher degree of waste treatment would be to increase tax burdens unjustifiably.

Varieties of Pollution Controls

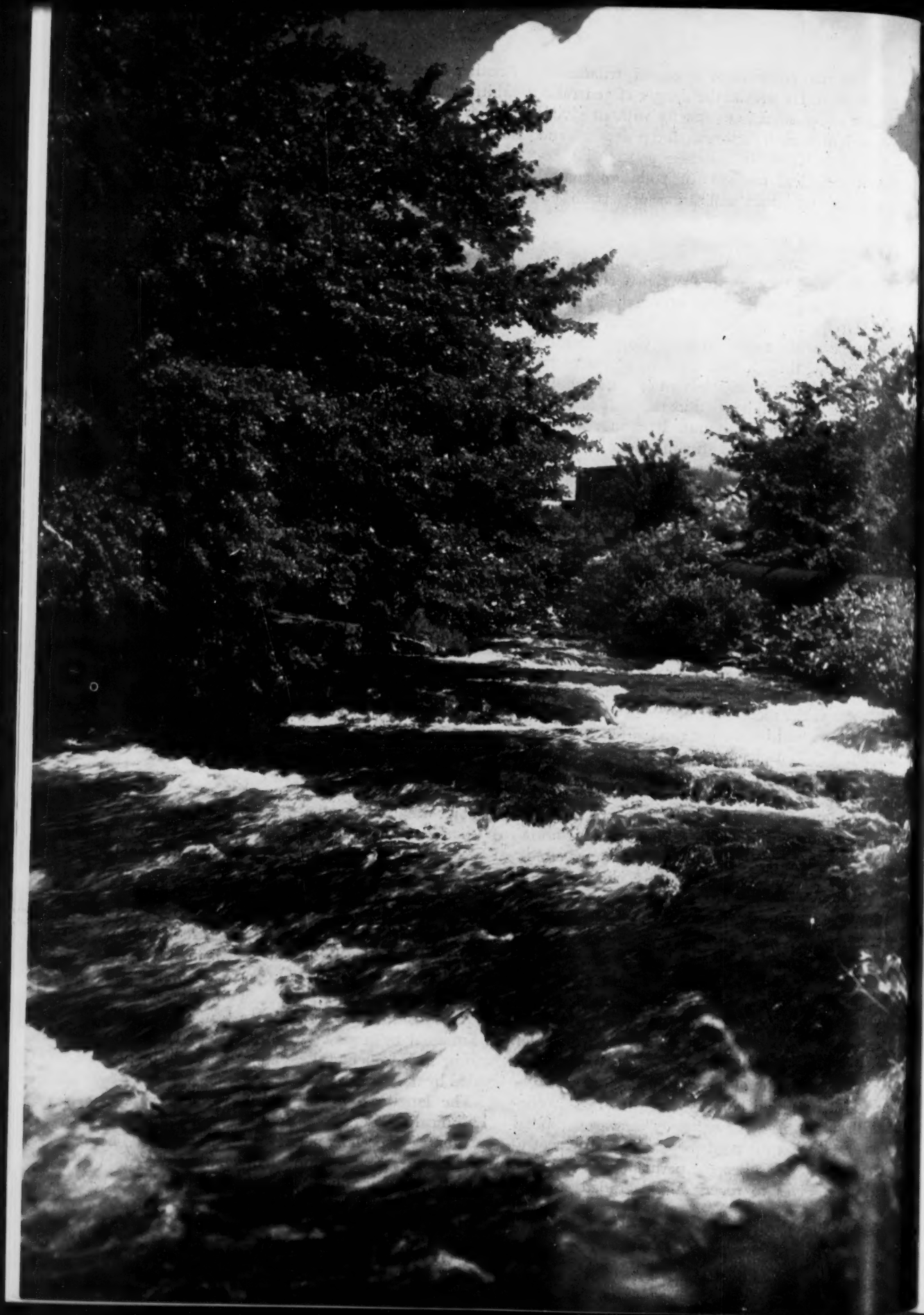
The earliest practical stream control was an attempt to limit discharge of oxidizable matter to a definite ratio of waste to stream flow. Figures ranging from 2 to 10 cfs of flow per thousand population were suggested, depending on the degree of turbulence of the receiving water. This type of control was proposed before the mechanism of deoxygenation was completely developed, and it could not take proper account of self-purification.

At present, many states have adopted one or another variety of stream classification. This is a highly useful administrative device, but it is not a sound way to regulate pollution. Temporary classification of streams to systematize a clean-up program can be quite helpful, but permanent classification can be self-defeating. A progress report of the Committtee on Water Quality Criteria of the California Water Pollution Control Board[13] points out that there is a tendency for a general pattern of water quality zones to develop in any area of varied topography, but it cites the following disadvantages of stream classification: uses of water are not uniform within a zone; effects of pollution are not uniformly dispersed throughout a zone; successful pollution control programs must recognize that the need for economy in waste disposal is as exacting as the need for water quality protection; zones tend to become permanent and do not lend themselves to reclaiming degraded streams. Another objection would be the tendency for the arbitrary line dividing two zones to move slowly farther and farther into the better of the two, as, for example, where a stream flows into the countryside from an industrial area.

A movement has been in progress for some time to place definite limitations upon certain physical, chemical, and biological characteristics of waste water, and to call these limitations "standards." It is unfortunate that the word "standard" has such a strong appeal for administrators; perhaps this has come about as a result of the general desire in this country to standardize everything from machine screws to thought patterns. But standards are basically improper when applied to pollution control, because their legal connotation tends to develop an inflexibility that cannot be readily adjusted to the dynamics of stream ecology. In addition, they promote avoidance of that thoughtful appraisal that is due each pollution problem if the best public interest is to be served. This viewpoint is supported by a number of authorities and organizations that have dealt with the question of standards.[13–16]

This by no means suggests that all qualifications of waste water should be discarded forthwith. It does emphasize that each situation should be dealt with on its own merits, and that promulgation of general standards prevents reaching the best solution in specific cases. In approaching the problem of stream water quality, the first step should be a comprehensive survey to provide data that can be used to determine those stream conditions that will be most appropriate for a given area. The recommended conditions will, in most cases, be better than those existing, but the survey will indicate a water quality that is reasonably attainable. It should therefore be the objective of the pollution control agency to provide this desirable quality, but the time required to reach the goal may be long or short, depending on local conditions. This does not prevent the agency from setting successively higher goals if economic circumstances and the general welfare warrant them. Once an immediate objective has been decided upon, water use can be allocated among municipalities and industries in terms of the pollution load that can be assimilated by a given stream section. Data that can be used to define these allocations will be provided by the survey.

The language of the report of the Board of Technical Advisers to the International Joint Commission[17] is especially pertinent to this subject. The report states that stream quality objectives could be set and maintained for a long period, but the



requirements for effluents might change with conditions. The objectives adopted are based upon the conditions that follow thorough admixture of effluents with the receiving water. The flexibility of the objectives is shown by the farsighted wording used. The report states that "adequate protection should be provided if . . ." the river water is maintained within a designated range of physical and chemical characteristics. Similarly for effluents, the desired "quality in the receiving waters will probably be attained if . . ." effluents are held within a range of specified compositions. This kind of procedure should result in maximum beneficial use of stream water.

Biological Indices

In recent years, considerable attention has been given to the perfectly reasonable proposition that aquatic life should be capable of yielding a satisfactory index of stream conditions. It has been maintained that streams supporting a diversified aquatic population distributed among those flora and fauna that persist only in clean water should provide a wholly acceptable water quality. Actual investigations have demonstrated that there is a practical biological technique that can be employed to distinguish degrees of pollution.

A significant comprehensive study in this field was undertaken by the Academy of Natural Sciences of Philadelphia.[18] It was sponsored by the Pennsylvania Sanitary Water Board, following a recommendation by the Pollution Abatement Committee of the Pennsylvania State Chamber of Commerce. This investigation showed that stream biota can be used to indicate a wide range of stream conditions from healthy to grossly polluted. It was concluded that direct measure of the biodynamic cycle discloses the presence or absence of all major taxonomic groups that play a role in the cycle; that chemical and physical characteristics of healthy streams vary widely and cannot be reduced to a simple standard; that there is no practical way to test for all toxic agents in a stream, and it is seldom that a single agent acts independently as a limiting factor; and that the biodynamic measure will reflect water conditions that existed for a considerable time, whereas a water sample represents only the condition at the time it was taken.

Application of biological methods in pollution control would disclose the rate of change of water quality in terms of the biota it supports. This would provide an invaluable record both for industries and administrative agencies. A simplified survey method is being developed by the Academy that should broaden its practical applicability. The new technique involves suspension of a coated plate in the stream to collect a representative sample of the phytoplankton and other free-swimming organisms.

Van Horn[19] has discussed biological indices and listed organisms characteristic of various degrees of pollution. He emphasizes that biological methods are not intended to supplant, but rather to supplement, other measurements, because of the inherent complexity of the phenomena involved. Chemical data may be considered as describing the cause, and biological data the effect, of a stream condition. Tarzwell and Palmer[20] note that a number of algae have been recognized as indicators of general water conditions, and suggest basic research to select those forms that can be relied upon to give specific information on impending changes in water quality. They also recommend development of a year-round biological sampling service.

Instruments as Control Devices

The measures that can be used to control pollution are of two broad, more or less interdependent, kinds. The first includes all the precautions that should be taken to reduce pollution at its source. The second is appropriate treatment of residual wastes. Instrumentation can be used effectively to regulate pollution control devices in many ways.

Stream pollution problems arise almost wholly from the discharge of water-borne wastes. A variety of instruments, some evolved from laboratory analytical tools, is available for measuring certain important characteristics of waste water, and of natural streams and lakes. Although commercial instruments for measuring every significant variable are not yet being marketed, it is probable that research will develop practical devices for complete control of waste water.

It should be obvious that pollution from industrial sources can best be abated by reducing the quantity of water-borne waste. This means careful control of manufacturing operations to keep discharges to a minimum consistent with satisfactory product quality. A waste water survey will generally disclose places where unnecessary waste is occurring. This may range from extravagant use of water to serious losses of raw material and semi-finished products.

The advantages of instrument control of processes over manual operation are too obvious to need much discussion. It is difficult to imagine a process that would not require one or more instruments

Clean, pure water flows from Naomi Lake in the Poconos.

for satisfactory operation, and many modern processes could not be operated at all without accurate instrument control. It is true that instruments sometimes fail to operate properly, but where adequate maintenance is provided they are generally more dependable than an operator: their response is faster and their attention does not wander.

The basis of all process control is measurement, but adaptation of a measuring device to a control instrument is not always easy, because measurement can be performed with a minimum of power but control cannot. Development of a powerful control action by amplification of the minute impulse of a measuring device results in design problems that often require a high degree of ingenuity. Nevertheless, keen competition among instrument manufacturers has provided the engineer with devices that can control a wide range of process variables. It is instructive, and in a sense prophetic, to observe the rapidity with which devices long considered to be useful only as laboratory analytical tools are being converted into control instruments.

Instrument control of processes to prevent waste may range from a simple warning device, such as a pH element for sounding an alarm when acid or alkali exceeds a limiting value, to full process control. Where a plant must be installed to modify residual wastes, instrument control can be quite effective, even though waste treatment control is usually much more complex than manufacturing process control, because of unpredictable variations in volume or composition. Where maximum limits have been established for certain components of an effluent, instruments can sometimes be employed to indicate a number of variables.

Ponding of anthracite silt to prevent stream pollution.

There is a growing conviction that streams themselves must provide the final criteria of what may be discharged to them. This attitude reflects an acknowledgment of the economic importance of streams as an agency for assimilation of the wastes of civilization. At the same time, it recognizes the rights of downstream riparian owners, the capacity of streams for self-purification, and the aesthetic and recreational values of undefiled bodies of natural water.

Our knowledge of the specific effects on stream ecology of most materials regarded as pollutants is

rather meager, and the data we have is limited to fairly definite conditions. For this reason, it seems illogical and uneconomical to set arbitrary limits for various constituents of plant effluents where knowledge of their effects is lacking. Such requirements are somewhat more defensible if they relate to the concentration of a given waste component after thorough dispersion in the receiving water.

Certain of the physical and chemical factors that affect aquatic life are fairly fundamental, and might be combined to provide a broad index of stream condition. Four factors affect stream biota directly: temperature, pH, dissolved solids, and dissolved oxygen. The effects of two others, turbidity and color, are usually indirect through their influence on photosynthesis. If the variation of these six factors, plus stream stage and effluent flow rate, were continuously recorded, there would be available a history that would be invaluable in deciding responsibility for unsatisfactory conditions. The relative importance of the items suggested might not be unanimously agreed upon, and means for combining them into an index of water quality might be difficult, but the proposal is worthy of research attention. Substances that cause serious effects in minute concentration, such as direct-acting toxins and taste-producing compounds, could not be evaluated in this manner, but these have always posed special problems.

Devices for continuously recording temperature, pH, stream stage, and flow rate are commonplace. Instruments for recording dissolved oxygen and conductivity are available but somewhat unfamiliar. Turbidity and color present a more difficult problem. Although there are instruments for measuring both, turbidity is a function of the size, shape, and number of suspended particles, and color measurement depends on transmitted light. Variation of these physical properties might cause calibration difficulties.

This combination of instrument-measured factors would serve an important purpose by providing an indisputable permanent record of stream and effluent quality. The function of waste treatment

Fertile farm land can be seen along our country's clean streams.

is not only to overcome local pollution problems but to effect a gradual improvement in the quality of surface waters. Means for obtaining a continuous record of conditions would help immeasurably in achieving this objective.

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Water Witching: An Interpretation of a Ritual Pattern in a Rural American Community

EVON Z. VOGT*

Evon Vogt was born in, and grew up near, Gallup, N. M. He has done considerable field research among the Navahos, the Zunis, and the Spanish- and Anglo-Americans of his native Southwest. He took his Ph.D. in anthropology at the University of Chicago in 1948, after which he was an instructor in social relations at Harvard and assistant director of the Laboratory of Social Relations project on "A Comparative Study of Values in Five Cultures." He is one of the authors of Navaho Means People *(Harvard University Press [1951]). At present Dr. Vogt is assistant professor of social anthropology at Harvard and an assistant curator in the Peabody Museum.*

THIS paper will attempt an interpretation of the phenomenon of water witching as a folk-ritual pattern which has been extraordinarily persistent in rural American culture and which has not been replaced by the services of competent ground water geologists in locating family-size wells in countless rural American communities. There is a vast literature on this water-divining pattern,† but by and large the writings have centered on the problem of whether dowsing does or does not work as an empirical technique for locating underground supplies of water. The latest publication of note in this vein is the best seller by Kenneth Roberts, *Henry Gross and his Dowsing Rod,* which, as a spirited defense of the empirical validity of the dowsing technique, has renewed and publicized the age-old controversy. But, so far as this writer has been able to determine, there has been no systematic attempt to analyze the phenomenon as a folk-ritual pattern functionally equivalent to the magical practices found in the nonliterate cultures of the world.

Emanating from the writings of Pareto, Malinowski, and Weber, and continuing in the present generation of theorists—notably Parsons, Kluckhohn, and Homans—a general body of theory concerning the function of ritual in the situation of human action has emerged. Briefly stated, the essence of this theory is that when human beings are confronted with situations that are beyond empirical control and that are, therefore, anxiety-producing both in terms of emotional involvement and of a sense of cognitive frustration, they respond by developing and elaborating nonempirical ritual that has the function of relieving emotional anxiety and of making some sense of the situation on a cognitive level.[2] Kroeber has recently questioned the universality of this relationship by pointing out that the Eskimos, who live in a far more uncertain and anxiety-producing environment than do Malinowski's Trobriand Islanders, have little ritual as compared to the Trobrianders, whereas given Malinowski's formulation one would expect more Eskimo ritual.[3] Kroeber goes on to indicate that the arctic environment is so severe that had the Eskimos devoted much energy to the development of ritual patterns, they would long

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† Tromp has compiled a bibliography of approximately 700 items on the subject of water divining.[1]

since have perished. This latter point is sound, but further analysis of Eskimo culture may reveal that, although there is little elaboration of ritual, the ritual patterns that do exist are still clustered around the greatest uncertainties of Eskimo life.

Others, notably Radcliffe-Brown,[4] have raised the issue as to whether rituals do not create anxiety (when they are not performed or are not performed properly) rather than alleviate it. Homans has treated this problem in terms of "primary" and "secondary" rituals focused around "primary" and "secondary" types of anxiety. Primary anxiety describes the sentiment men feel when they desire the accomplishment of certain results and do not possess the techniques that make these results certain; secondary anxiety describes the sentiment resulting when the traditional rites are not performed or are performed improperly.[5] Kluckhohn has carried the analysis further by demonstrating that ritual patterns have both a "gain" and a "cost" from the point of view of the continued functioning of a society, and that problems are created as well as solved by the presence of ritual patterns in a given culture.[6]

Finally, I should like to advance the theory that ritual patterns which initially emerge as responses to critical areas of uncertainty in the situation of action are elaborated and reinterpreted in terms of certain selective value-orientations in a given culture.‡

We are brought, then, to a dynamic conception of ritual which includes the following considerations: Ritual patterns develop as a response to emotional anxiety and cognitive frustration in a situation of uncertainty; but ritual patterns come to have both "functional" and "dysfunctional" aspects (both a "gain" and a "cost") for the continuing existence of a society as the patterns are elaborated and developed in terms of the selective value-orientations of a given culture.

In this paper I shall analyze the relationship of the water-witching pattern to the critical area of uncertainty in the location of underground water supplies, explore the functional and dysfunctional aspects of this pattern for the continuing survival of the community, and try to show how the pattern has become an expression of the value stress on "rational" environmental control in a rural American community.

Folk Ritual in Rural America

The continuing existence of a large body of folk ritual in rural American culture is a fact of common observation by anyone who has lived in such communities and by those who have done systematic research in rural areas. For example, in *Plainville, USA,* James West wrote that "many magical practices still exist for planting crops, castrating livestock, weaning, gardening, girdling trees."[7] Taylor reported that he had gathered 467 different signs and superstitions that are known and to some extent believed in rural communities.[8]

Although these magical practices are found in connection with many aspects of rural culture, including the preparation of food, the curing of illness, and the weaning of babies, they are apparently concentrated in the area of farming technology and have to do mainly with weather, crops, the care of animals, and the locating of water wells. Taylor asserted that over one fourth of his 467 signs and superstitions refer to climate and weather and that the majority refer to plants and animals in addition to weather and climate.[8]

The Water-Witching Pattern

The phenomenon by means of which one is supposed to find underground supplies of water by the use of a divining rod is variously known as dowsing, divining, witching, and rhabdomancy. The indicator employed in water divining is called a divining rod, witching stick, dowsing rod, dipping rod, striking stick, or wand; and the practitioner may be called a diviner, dowser, witch, or finder. In current usage the word "dowsing" is more common in the literature and is used by rural people along the Eastern seaboard; "water witching" is the more common term used by rural folk who utilize the technique in the South, Middle West, and Far West.§

It is certain that the water-witching pattern has a respectable antiquity in Western culture and it is highly probable that the basic ideas of the technique derive ultimately from ancient divining practices that are widespread among the nonliterate cultures of the world. The "rod" is mentioned many times in the Bible in connection with miraculous performances, especially in the books of Moses. The much-quoted reference to Moses' striking the rock with his rod, thus producing water for his followers in the wilderness (Numb. XX: 9–11), has been regarded by enthusiasts of water witching

‡ This theoretical point will be developed in the writer's forthcoming publication on *The Homesteaders: A Study of Values in a Frontier Community.*

§ Roberts objects to the use of the term "water witch" on the ground that it perpetuates the idea of its association with witchcraft and prefers the term "dowsing."[9] "Dowsing" comes from the Cornish word *dowse* and the Middle English word *duschen,* both meaning to strike or to fall. "Rhabdomancy" comes from two Greek words, *Rhabdos* ("rod") and *manteia* ("divination").

as a significant reference to the divining rod.[10] Herodotus mentions the use of the divining rod by the Persians, Scythians, and Medes; and Marco Polo reports its use throughout the Orient.[11]

But whatever significance one may attach to such references, authorities agree that the divining rod in its present form was in use in Germany by the first half of the sixteenth century.[12] The first complete published description is contained in Agricola's *De re metallica,* published in 1556.[13] Barrett considers that the birthplace of the modern divining rod was in the mining districts of Germany, probably in the Harz Mountains, where it was used to prospect for ore. During the reign of Queen Elizabeth (1558–1603), when German miners were imported to England to lend an impetus to the mining industry in Cornwall, they brought the *schlagruthe* ("striking rod") with them. As mining declined in Cornwall, the use of the rod was transferred to water finding.[14] At about the same time there is mention of the use of the rod for locating water supplies in France.[15]

Before the end of the seventeenth century the use of the divining rod had spread through Europe, everywhere arousing controversy. Its champions, among whom were some of the most learned men of the time, explained its operation on the principle of "sympathy" or "attraction and repulsion." Its adversaries, like Agricola, condemned its use as a superstitious and vain practice.[13] Indeed, the practice even became a subject of ecclesiastical controversy when Martin Luther proclaimed in 1518 that the use of the rod violated the First Commandment,[16] and the Jesuit Father Gaspard Schott later denounced it as an instrument controlled by the devil.[17] From Europe the water-witching pattern spread to the New World and to such regions as Australia and New Zealand,[18] and it is reported that as late as 1931 the government of British Columbia hired an "official" water-diviner to locate wells.[9]

Over the past four centuries the phenomenon has also been the subject of innumerable scientific (or allegedly scientific) investigations and controversies, beginning with Pierre Lebrun in 1692[12] and continuing off and on to the present controversy stimulated by Roberts' best-selling book.[9] The key figures in these investigations and controversies have been such men as Sir William Barrett (professor of physics in the Royal College of Science for Ireland), Henri Mager (in France), J. W. Gregory (Glasgow University), O. E. Meinzer (U. S. Geological Survey), and more recently Solco W. Tromp (professor of geology at Fouad I University, Cairo).

The core of the water-witching pattern as it is now found in rural American culture may be characterized as follows:

Equipment. The most common item of equipment utilized is the witching stick, typically a Y-shaped green twig cut from a hazel, willow, or peach tree. The two forks vary from 14 to 18 inches in length, and the neck from 4 to 11 inches. The diameter of the stick may vary from one-eighth inch to almost an inch. Alternative types of wood used include maple, apple, dogwood, and beech twigs and, in the southwestern United States, twigs cut from piñon and juniper trees. There is even one case on record of a diviner who uses a leaf from the broad-leafed yucca plant.[19] Less common, but widespread, are various metallic materials used for witching, including barbed wire from the nearest fence, a clock or watch spring, and especially constructed aluminum rods. Finally, some water witches use various kinds of pendulums such as small bottles of "chemicals" suspended on a string, or a key suspended by string from either a Bible or an arithmetic book.

Technique. The most common technique is to grasp the two branches of the forked twig, one in each hand, with the neck (or bottom of the Y) pointing skyward. Usually the twig is grasped with the palms of the hands up, but an alternative method is to hold the stick with the palms down.[20] In either case, the forked twig is placed under tension in such a way that the slightest contraction of the muscles in the forearm or a slight twist of the wrists is sufficient to cause the twig to rotate toward the ground. The water witch walks over the ground in the area where a water supply is desired. When he walks over an underground supply of water, the witching stick is supposed to dip down, and a stake is then driven into the ground to mark the spot. Although most dowsers function only to locate a suitable spot to drill for a well or to dig for a spring, some also have techniques for determining the depth of the water supply. Perhaps the most common of these is to measure the distance from the place where the stick starts to dip to where it dips straight down over the water supply. Few, if any, other practitioners profess to have the sophisticated "powers" of Henry Gross that would enable them to ask questions and receive answers (by the way the rod nods) as to the quality and amount of the underground water, or to locate a water supply by "long-distance" dowsing, as Henry Gross did when he dowsed over a map of Bermuda while in New England and located water there.[9]

Ideology. Like most ritual patterns, water witching carries with it an elaborate mythology, the core of which involves two aspects: the dowser's definition of the geological situation, summarized by the belief held by dowsers that underground water occurs in two forms: *sheet water,* which underlies a total area, and *water veins,* which may vary in magnitude from "the size of a pencil" to "underground rivers" and which run through the earth like the veins in the human body. The important thing is to locate and trace these veins, because either there may be no sheet water in a given area or it may be located at so deep a level that the only way to find suitable shallow water is "to hit a vein." The most elementary knowledge of ground water geology is sufficient to prove that this dowsing concept bears little relation to known facts. The second aspect concerns the many and varied "explanations" and justifications advanced by dowsers for the efficacy of dowsing and the rationaliza-

tion provided to account for failures. The "explanations" on record range from supernaturalistic interpretations (such as the notion that dowsers derive their mysterious power from Moses, "who was the first water witch") to supposedly scientific interpretations (such as the notion that the muscles of the water witch are affected by electromagnetic disturbances emanating from underground water supplies). Most of the ordinary and less articulate water witches in rural America provide explanations in terms of (1) a kind of magical principle by which the water in the green twig is attracted by the water in the ground, or (2) a theory—which they regard as "scientific"—that the dipping of the stick has something to do with "electricity" or "electrical currents" which run from the water through their bodies and into the stick, causing it to dip. Equally important are the rationalizations advanced to account for failures. These typically take the form of attributing the failure either to faulty equipment (e.g., "I couldn't find a straight stick that day") or to some aspect of the situation that negates the findings of the dowser (e.g., "I found I had a knife in my pocket which short-circuited the electric current," or "The vein dried up before they got around to drilling the well").

Institutionalization of Role. There is considerable variation in the prestige the dowser has in a rural community, depending upon various factors. But it is clear that he occupies a special role. In the first place, the basic ability to do witching is usually believed to be a skill with which one is born and which he later discovers; it cannot be acquired by training or experience. In this respect it comprises a skill which is acquired by "divine stroke," as in the "shamanistic" tradition, rather than a body of knowledge transmitted by training in a "priestly" tradition. To be sure, it is necessary for a person to have observed (or to have heard about) the basic techniques, but it is impossible for one water witch to impart the skill to another. One is either born with it or one is not.‖ By virtue of this inborn ability, the dowser assumes a specialized role that is recognized by the total community—both by the proponents and by the adversaries of dowsing.

In the second place, the water witch is almost always paid for his services, in amounts ranging from $5 to $25 (in the Southwest) for locating each well site. In this respect his position becomes a part-time occupation, and some dowsers derive a substantial income from their activities. It should be pointed out that some dowsers charge a set price and collect the money in businesslike fashion; others volunteer their services and take whatever contributions are offered them. But I have not yet known a water witch who was a charlatan or who performed the operation purely for the monetary gain involved. Usually they are sincere individuals who believe thoroughly in their ability to find water. Finally, it should be noted that dowsers are usually men, although women sometimes have the witching skill. Indeed, the water-diviner reported to have been employed by the government of British Columbia in 1931 was a woman.

‖ However, there are reputedly differences among dowsers as to the amount of skill they possess. Thus Roberts describes Henry Gross as being a highly skilled dowser.[9] And once a dowser finds that he has the basic ability, it is possible for him to become more skilled with experience. It would be interesting to know the incidence of dowsing skill in the rural population, but no data are yet available. It is worth noting that in the community of Homestead (pop. 250) there is one dowser; and in the nearby Mormon community of Rimrock (pop. 300) there is only one. Neither community has ever been without at least one dowser. For short periods of time there have been two in each community, but never more than two at any given time.

Having described the history and general pattern of dowsing, let us turn to a more intensive treatment of water witching in terms of the concrete data from a single community—Homestead, New Mexico¶—where the relevant historical, geological, and social facts are well known.

Water-Witching in Homestead**

The community of Homestead was established by families from the South Plains area of western Texas and Oklahoma who settled on homesteads in the semiarid area of western New Mexico in the early 1930s. The economy focuses around the production of pinto beans on dry-land farms, supplemented by crops of corn, winter wheat, and beef cattle. Farms now average two sections in size and are scattered as far as twenty miles from the crossroads center of the community which contains the stores, school, post office, repair shops, and other service institutions. Farming technology has shifted through the years from horse-drawn implements to mechanized equipment.

The natural environment provides an unusually hazardous setting for dry-land farming. Until the homesteaders arrived, the land had been used only for grazing purposes, and the area is still regarded as submarginal farming land by authorities in the U. S. Department of Agriculture. The soil is excellent for beans, but the necessary 90-day growing season is often cut short by late spring frosts or early fall frosts at this elevation (7000 feet). Heavy windstorms in the spring add the hazard of serious wind erosion. But the basic environmental problems are those of inadequate and fluctuating rainfall and the development of water resources for livestock and household use. Annual precipitation averages 12.5–15 inches, depending upon locality and elevation, but has varied over the past two decades from 6 to 19 inches.

The people who established this community defined themselves as pioneers, leaving the "civilized" centers of Texas and Oklahoma to seek new homes on the "frontier" west of the Continental Divide. As pioneers, they emphasize many of the values characteristic of newly settled American farming

¶ Homestead is a fictitious name, used to protect the anonymity of my informants.

** The data from Homestead are based upon a year's field experience in the community during 1949–50. Additional data on this community will be provided in the writer's forthcoming monograph on *The Homesteaders*.

communities: a stress on self-reliance and independence of the individual, a drive to subdue and control the natural environment, an abiding faith in the progressive development of their community, and a perennial optimism about the future. With these values they confronted the semiarid environment of western New Mexico and set about the business of developing dry-land farms.

One of the first critical problems the homesteaders faced was the development of adequate water supplies. When they first arrived in 1930–31, they found it necessary to haul water in barrels by team and wagon from a lake three miles from the center of the community. When the lake went dry, they hauled water from a spring seven miles distant. If a farmer had livestock, it meant that he had to haul water at least every other day. A few tried drilling wells in the early years, but it was soon discovered that, although in some places water was struck at shallow depths (80–100 feet), in others dry holes were the only result after drilling over 500 feet. At a cost of $1–$3 a foot for drilling a well, few homesteaders were willing or able to take the risk.

It was in this situation that one farmer suddenly "discovered" in 1933 that he had the "power" to witch for water. As a young boy in Texas he had observed witching. One day he simply cut a forked stick from his wife's peach tree, tried out the technique as he remembered it, and it worked. He found two water veins on his farm, traced them to a point where they crossed each other, and had a successful well drilled at this spot at a depth of 230 feet. He rapidly achieved community-wide reputation as a water witch and successfully witched 18 wells in the next few years. Six wells were dowsed by a second water witch who lived in the community for a few years, making a total of 24 wells that were located in this manner. During the same period, however, the original water witch dowsed five locations where dry holes resulted after drilling; and he often missed calculating the depth by as much as 200–400 feet. For, in addition to using the common technique for locating the water vein by walking over the ground with a forked twig and putting a stake in the ground where the rod dipped, he developed a special technique for determining depth. He would hold a thin, straight stick (5 feet in length) over the water vein, and it would "involuntarily" nod up and down. The number of nods indicated the depth in feet to the water. During the same period 25 wells were successfully drilled without benefit of dowsing, and seven dry holes were drilled in locations that were not dowsed (Table 1).

As time went on, the water witch killed his wife's lone peach tree by cutting witching sticks from it. He then made an adjustment to the New Mexican environment by shifting to the use of forked twigs from piñon trees. He explains his dowsing in terms of "electricity" and usually attributes errors to the presence of iron (like a knife in his pocket, or an old piece of farm machinery in the vicinity) or to the fact that he could not find a straight stick.

There is, of course, more than a casual relation between the early water supply problems of homesteaders and the geology of the Homestead area.†† The community is bordered on the south by a high escarpment that exposes the upper formations underlying the area. These consist of Quaternary basalt flows which are exposed in portions of the eastern and northern parts, Tertiary sands and conglomerates which underlie the western part, and the Mesa Verde formation of Upper Cretaceous age which underlies the above formations at variable depths. The Mesa Verde formation is about 1800 feet thick and consists of alternating gray to buff sandstones, gray clay shales, and coal.

During Tertiary time the shales and sandstones of the upper Mesa Verde formation were eroded, and subsequent deposition of the Tertiary sands and conglomerates filled the old channels. The existence of these buried channels and ridges, and recent erosion of the Tertiary formation, resulted in variations in the thickness of the Tertiary formation and the upper member of the Mesa Verde formation.

Ground water occurs in the Mesa Verde formation, which is the main aquifer, and in the Tertiary formation; small quantities may also be available in the recent alluvium in the valleys, especially in the north and northeast. Structural conditions are not well known, but there are indications of a number of faults and of one syncline, which also affect ground water supplies.

Several shallow wells near the center of the community and a few wells to the west obtain water from the Tertiary formation. These wells range in depth from 225 to 260 feet, and the yield is usually small. The erosion of the Mesa Verde

TABLE 1

	Wells Divined	Wells Not Divined
Successful wells	24	25
Dry holes	5	7

†† I am indebted to Tom O. Meeks for the geological data.

formation, and subsequent deposition of the Tertiary formation, have caused the base of the Tertiary sands to be an irregular surface. This accounts for the variable depth of wells and the variation in yields. Wells drilled into the old channels are likely to yield more water than others drilled on the buried ridges of the underlying Mesa Verde formation.

The majority of wells in the Homestead area, and all the wells a mile or more east of the center of the community, obtain water from the Mesa Verde formation. The yield of these wells is generally greater than those obtaining water from the Tertiary sands, but it is necessary to drill deeper. The depth varies from about 80 feet in the Tertiary sands in the western part of the area to 800 feet in the Mesa Verde formation in the eastern portion.

Thus it is readily seen that geological conditions have resulted in substantial variations in ground water resources in different parts of the area. In some localities water is found in the Tertiary sands, usually at relatively shallow depths, but with variations running from 88 to over 300 feet. In other localities it is necessary to drill to a greater depth into the Mesa Verde formation. And the situation is further complicated by structural conditions that are not yet well known by geologists.

In the dowsing of his own well the local water witch was over the Tertiary formation, and water in small quantities was located at 230 feet. The wells which the dowser "successfully" located were either drilled into the Tertiary formation or the farmers were willing to drill to greater depths and thus reach the Mesa Verde formation. The dry holes were cases in which the wells were either (*a*) located where the Tertiary sands did not exist and the farmer was unwilling to go deep enough to strike the Mesa Verde formation (two cases), or (*b*) located over the Tertiary formation but in places where buried channels or the presence of the syncline in the underlying Mesa Verde formation made the depth to water greater than the wells were drilled (three cases). The same geological facts account for the dry holes that resulted from drilling in locations that were not dowsed. The frequent errors in estimating depth were undoubtedly due to these same geological conditions, especially since the dowser usually named a depth that approximated, or was less than, the depth of his own well.

In addition to the water-witching pattern there are two other types of institutionalized folk ritual in Homestead: (1) the use of natural phenomena, such as the winds, clouds, or moon to predict the weather (especially the occurrence of frost) and to judge the proper time for planting crops; and (2) the use of the signs of the zodiac to know when to perform certain farming or livestock operations,‡‡ such as when to castrate calves "so they won't bleed to death," when to wean calves "so they won't bawl around for several days,"§§ or when to hoe weeds "so they won't come up again." Farmers who believe in and practice these three types of folk ritual are known, respectively, as "witch men," "moon men," and "sign men."

Not all the homesteaders believe in and practice these rituals. Our data indicate that opinions range from those of farmers who are wholly oriented in terms of the rational-technological methods of modern agricultural science and scoff at "those silly superstitions," to those who believe firmly in and practice all three types of ritual—e.g., the water witch who is also full of knowledge about and belief in "signs," "planting by the moon," etc. The data further indicate that, of the three areas of ritual, the water-witching pattern is the most widespread and the most persistent in the face of formal education in the theories and methods of modern science. When the recorded instances of the practice of these rituals from our running field notes for the year's period were classified, it was found that 57 per cent of the instances were in the area of water witching, 29 per cent were in the area of the use of the almanac and the signs of the zodiac, and 14 per cent referred to the use of natural phenomena to predict and control events.[21] It was further discovered that some of the most highly educated individuals in the community were having wells dowsed (for example, the principal of the school, who possesses an M.A. degree). Again, research revealed that opinion varied from utter skepticism on the part of some farmers who said that "the best witching stick is the end of the driller's bit" to complete faith in the ability of the dowser to locate water. The most frequent response was an attitude expressed by such statements as, "Well, I'm not sure I believe in it, but it don't cost any more," or "I'll always give it the benefit of the doubt."

Comparative data from a recent study in the

‡‡ For the signs the homesteaders depend mainly upon *Dr. J. H. McLean's Almanac* (now in its 98th year of publication), which is distributed free through the local stores by the Dr. J. H. McLean Medicine Company, of St. Louis.

§§ The same sign is used to judge the proper times to wean infants. Other researchers interested in the socialization process in Homestead were startled when the response to their question "When do you wean your babies?" was "I wean them when the sign is right." This would appear to be an aspect of the socialization process in rural America that has not yet been explored.

Texas Panhandle, which was initiated to provide controls over certain variables in the Homestead study, are illuminating for the analysis of water witching.[22] The Panhandle study was focused on the small community of Cotton Center (pop. 100), near the geographical center of the area that provided the families for the present population of Homestead. The kinship and intervisiting ties between the two communities are unusually close, despite the distances involved, and there is ample evidence that the cultures of the two communities are still quite similar.

Specific inquiries as to water witching and the geology and ground water resources were made in Cotton Center. The community is located in Hale County, which is extremely flat, consisting of slightly undulating hills interspersed with many poorly drained depressions that fill with water during the rainy season. Annual rainfall averages 22 inches, or almost twice the precipitation found in Homestead. Most of the usable ground water is found in the Ogallala formation, a sandy deposit lying at or near the surface throughout the region.[23] The ground water table stands at a depth of about 125 feet below the surface, and good wells can be obtained at almost any point. Wells are located where water can be used to best agricultural advantage on the farms. Water witching is widely known, but it is almost never practiced. It can be classified as an unused skill in Cotton Center.

There is also evidence from this area of the Panhandle to indicate that the practice of water witching in Homestead is not due to selective migration —with the "superstitious people" moving west to New Mexico and leaving the families with a more rational-technological orientation behind. For, less than 25 miles to the southeast of Cotton Center in Floyd and Crosby counties, the ground water situation is more variable, there is more difficulty locating wells, and water witching is currently practiced. Indeed, there are men from Cotton Center who assist their relatives in dowsing for water in these other counties.

Alternative Theories of Water Witching

There are three theories to account for the persistence of water witching in rural American culture. The first may be designated as the "technological theory," which accounts for the continuing practice of water witching on the basis of the empirical validity of the technique as a reliable method for locating wells. The second theory may be designated as the "survival theory," which assumes that water witching is a folk-ritual pattern but accounts for its continued practice by defining the pattern as a "survival" from a previous, less technically oriented phase of our cultural development. The third theory may be designated as the "functional theory," which also defines water witching as a ritual pattern but emphasizes the relationship between situations of technological uncertainty in the present scene and the pattern of water witching as a ritual means of coping with situations that are beyond empirical control.

The Technological Theory

As indicated earlier, the controversy about water witching has centered around the problem of whether it does or does not work as a reliable empirical method for locating underground supplies of water. This theory must be examined first, because if water witching is an empirically reliable technique, it can then be regarded as part of the rational farming technology in rural American culture, and no further explanation of its continuing use is necessary.

It would be patently impossible to summarize here all the arguments pro and con on the empirical validity of water witching; our task is merely to examine the most relevant evidence. At the outset we may rule out the various "supernaturalistic" claims—as, for example, the claim that dowsers have some kind of mysterious power transmitted through the generations from Moses which enables them to find water. We may also eliminate the simple explanation of many dowsers to the effect that the water in the ground attracts and pulls the water in the freshly cut witching stick. There would appear to be no naturalistic basis for believing that water located (in some cases) as much as several hundred feet under the surface could directly affect the water in a freshly cut stick. Furthermore, as Finklestein points out, the claims of the dowsers lead one to the inevitable conclusion that if there is an empirical basis for the technique, it must be independent of the type of witching device utilized; because the same claims are made for the effectiveness of all devices.[21]

Although we may eliminate the possibility that some kind of external physical force acts directly upon the dowsing rod, there remains the possibility that some kind of external physical force is stimulating the dowser's muscles, which then contract and cause the rod to dip. In this case the rod is merely an indicator of muscular contractions and the type of witching rod used would make no difference.

This approach to the problem has recently been explored by Tromp, who presents experimental evidence indicating that some individuals are more

sensitive than others to changes in the strength and polarity of electrical fields associated with both natural and artificial objects.[1] And the problem then becomes one of assessing the possibility that underground supplies of water may affect variations in electromagnetic fields to the extent that these changes in electrical field strength are registered in the dowser's muscles, stimulating them to contract, and thereby indicating the presence of underground water. As matters now stand, even Tromp does not appear to claim that dowsers can identify the cause of a particular change in electrical field strength (such as might result from the presence of underground water), but only that it exists.[24] And the judgment of competent geologists is that it is impossible that changes in electromagnetic fields caused by the *specific* presence of underground water can be registered in *specific* ways in the muscular contractions of dowsers.‖‖

The question may also be raised as to whether the dowser is not merely a sound practical geologist who knows the ground water situation from experience in a given area, and that he is responding to certain surface outcroppings or other indications of underground water when his witching stick dips. In other words, perhaps the witching stick is merely an indirect way of communicating sound geological knowledge.

It is true that many dowsers respond to certain cues in the environment while they are going through the dowsing process. For example, the dowser in Homestead utilizes anthills, and piñon trees with branches that hang down unusually far, as general guides to underground water. But our evidence indicates that these are merely cues for the dowser and have no specific connection with shallow underground water. Furthermore, the dowser makes no attempt to collect information about the location and depth of other wells in the vicinity or to utilize other types of empirical data in the location of new wells.

In other areas of the world, however, there is suggestive evidence that the dowsers occasionally do possess some sound geological knowledge and that their "successes" are due to these empirical observations that are then recorded by the witching stick.[25] But in this case it is obviously the geological observations made by the dowser (and neither the attraction of the rod by underground water nor the stimulation of the muscles of the dowser by variations in electrical fields caused by the presence of underground water) which give the technique an empirical basis.

A second approach to the problem of the empirical validity of water witching is to examine the best evidence available as to the reliability of the dowsing technique. There have been two recent relevant systematic studies. In 1939 the New South Wales Water Conservation and Irrigation Commission issued a report containing full data on wells drilled in New South Wales from 1918 to 1939. The commission drills wells and issues licenses for wells drilled by private companies, so that full statistical data are available. Table 2 gives the totals from 1918 to 1939.[26]

TABLE 2

	Wells Divined		Wells Not Divined	
	No. of Wells	Percentage	No. of Wells	Percentage
Bores in which supplies of serviceable water estimated at 100 gal./hr. or over were obtained	1234	70.4	1406	83.9
Bores in which supplies of serviceable water estimated at less than 100 gal./hr. were obtained	180	10.2	88	5.3
Bores in which supplies of unserviceable water were obtained	82	4.7	55	3.3
Bores—absolute failures, no water of any kind obtained	257	14.7	126	7.5
Total	1753	100.0	1675	100.0

In 1948 P. A. Ongley, of the Medical School at the University of Otago, published the results of controlled experiments performed on 58 different New Zealand water dowsers. Not a single dowser showed any reliability in any of the experiments, which consisted of the following:

1. Asking the dowser to locate an underground stream and then return to it with his eyes closed.
2. Having the dowser locate an underground stream and then later identify which pegs were on the stream and which were not—the experimenter having placed one half of a number of pegs over the underground stream

‖‖ Personal communication from Kirtley F. Mather, April 10, 1952, as follows: "Although he [Tromp] claims that the results of his own experiments and those of other qualified scientists indicate 'that divining phenomena are not due to charlatanry and suggestion but really exist,' he also states that 'many diviners make the mistake of claiming that they are able to indicate certain hidden objects, underground ore deposits, water, etc. They fail to realize that many external influences can create the same physiological reaction, similar to readings with modern geophysical instruments, which could be the same under different external conditions.' My conclusion is that Tromp presents no valid evidence that there is any scientific basis, other than psychological, for the procedures followed by dowsers in their efforts to locate underground water supplies."

designated by the dowser and the other half of the pegs off the stream.

3. Asking two or more dowsers to check one another on the location of underground water.

4. Asking the dowser to say whether a hidden bottle was full of water or empty.

5. Asking two or more dowsers to determine the depth of the water below the surface of the ground.[25]

To these observed facts, we may add the data on dowsing from Homestead which are reported in Table 1. Although the number of wells involved is small as compared to the series from New South Wales, it is plain that the same negative results are indicated. In both instances, it does not appear to make much difference whether a well is dowsed or not; if anything, there would appear to be fewer complete failures when wells are located by methods other than dowsing, indicating that chance or common sense is a little more reliable.

Finally, I have observed two cases in Homestead in which the well driller was already drilling in a water-bearing formation when the water witch appeared with his forked twig and announced (after dowsing around the immediate area of the well rig) that the driller had best move his drill since he would never hit water in the hole he was then drilling!

It is difficult to avoid the conclusion that water witching is not an empirically reliable method for locating underground supplies of water.¶¶ It is plain that the witching stick dips in response to muscular contractions of the dowser that are due to some type of unconscious mental or psychic processes and *not* in response to the physical presence of underground water supplies. But the question remains as to why water witching continues to be practiced if it is not an empirical method for locating water. To answer this question we must turn to the other two theories.

¶¶ For an answer to the problem of how Henry Gross was able to locate wells in Bermuda by merely dowsing over a map, the reader is referred to Nichols' review of Kenneth Roberts' book on *Henry Gross and his Dowsing Rod*. Briefly, Nichols points out that limestone islands of the Bermuda type have little fresh water, because the limestone is so permeable that the rain water runs through it rapidly and mixes with the salt water. Most of these islands have a thin lens of fresh water floating on salt water, its thickness depending on the size of the island, the permeability of the rock, and the rainfall. The problem is not that there is no fresh water in Bermuda, but that there is not very much. What there is must be developed by a "skimming" process in which wells are dug to or just below sea level and the water is pumped at a rate that will keep its level just above that of the sea, thus preventing salt water from rising into the well. So Henry Gross did not locate "domes" of fresh water in Bermuda (where there was previously nothing but rain water trapped from the runoff of roofs); he merely located wells which reached to lenses of fresh water floating on the salt water.[24]

The Survival Theory

A second theory that is held implicitly, and sometimes stated explicitly, by many rural sociologists, government agricultural experts, and other observers of the rural scene is the view that water witching is one of many "superstitions" that survive among the unenlightened farmers who learned them from their fathers and grandfathers. It is firmly believed by these observers that the "superstitions" will be replaced by rational-technological methods for coping with the environment as soon as there is sufficient education in the methods of modern agricultural science. Indeed, the disposition of many of these writers is to behave as if the superstitions had already been replaced by scientific methods; and despite their prevalence in rural American culture, it is rare to find an explicit treatment of the problem in rural sociology textbooks. An exception is Sims, who writes that:

> The magical mind, rather than the scientific attitude, tends to prevail (in rural America). . . . This is an emotional and unreflective attitude which does not clearly perceive the steps between thoughts and actions. . . . Expressions of magical mindedness are seen in numerous superstitious beliefs and practices in regard to harvesting and planting.[27]

Sims goes on to argue that science will eventually cause the disappearance of ritual from the rural scene, as he writes:

> The impress of science is already marked and the agencies carrying it to the farmers persistent. . . . With much prestige already established for this method, there is every reason to think that fairly rapid headway will be made in the immediate future. To the degree such progress is made, the magical mindedness will disappear.[27]

There is certainly a grain of truth in this explanation of water witching. It *is* a "superstitious" practice from the point of view of the educated observer, and the pattern has obviously been transmitted to the current generation of farmers from earlier generations. But does it persist *merely* because farmers are lacking in education and are "magical minded"? Two observations on the basis of Homestead data may be made here. The first is that many of the most highly educated individuals in Homestead still resort to the practice when they have a well drilled. The second is the fact that although the educational level is approximately the same in the present population of Homestead as in the population of Cotton Center in the Texas Panhandle, water witching is not utilized to locate wells in Cotton Center (where the water table stands at a uniform depth), whereas the

practice flourishes in Homestead (where the underground water supply is highly variable in depth). These facts strongly suggest that there is more to the phenomenon of dowsing than that it is a "superstitious survival" from an earlier phase of cultural development.

The Functional Theory

A few rural sociological writers have given some attention to this third theory in which such practices as water witching are viewed not merely as "superstitious survivals" but as ritual responses to situations of technological uncertainty in the contemporary scene. Carl Taylor, in his *Rural Sociology,* has made the following statement:

> The reliance of the old time farmer upon the almanac was proverbial, and his belief in signs, although sometimes exaggerated, is by no means extinct. . . . The point we wish to make here is not that superstitions, signs, and charms have greater influence among rural than urban people (although this is probably the case), but that farming as an enterprise is influenced by the uncertainty of weather and seasons to such an extent that specious explanations of the causes and effects of this uncertainty have become widespread among rural people.[8]

In the elaboration and application of this functional theory to the phenomenon of water witching, we must first specify the aspects of the Homestead situation that are technologically uncertain (and hence productive of emotional and cognitive frustration) from the point of view of modern science. It is clear that a competent ground water geologist can provide a sound general description of the geology and the water resources of the region, and that this geological knowledge indicates that ground water is available in two of the formations that underlie all or part of the region. One or the other of these aquifers can always be reached if wells are drilled deep enough. But it is equally clear that even with the most careful geological mapping, there exists a high degree of uncertainty as to the depth and amount of ground water available in any *particular* location where one may choose to drill. This factor of indeterminacy arises from the fact that surface outcroppings do not provide complete knowledge of the buried channels and ridges that resulted from erosion of the Mesa Verde formation in Tertiary times, or of the structural conditions resulting from faults. Both these geological facts result in substantial variations in the depth and quantity of ground water.

We have, then, a situation in which family-size wells on the scattered farmsteads were needed to relieve farmers of the expensive and time-consuming task of hauling water from some distance, and a situation in which there existed a zone of indeterminacy in the exact location of adequate ground water resources. The stage was set, so to speak, for the development of a method to cope with the situation. Two things happened. On the one hand, a local farmer "discovered" that he had the power to dowse wells and began to do so throughout the community; on the other, geologists from the Soil Conservation Service began to visit the community and to make certain recommendations on the location of wells. The two alternative methods were in competition. But the geologists came to the community infrequently*** and could only provide answers to the question of location and the depth to water in a given well in *general* terms, whereas the water witch was always available and could specify an *exact* location and an *exact* number of feet to water. These reassuring answers encouraged many homesteaders to drill wells. When good wells were obtained at near the depth named by the water witch, his praises were sung throughout the community. When a dowsed well was a failure (because it was not deep enough), there were ready-made rationalizations to account for the failure. And the most frequent stories told about dowsing involve the cases in which a farmer tried drilling without dowsing and obtained a dry hole; then he hired the water witch to locate a well on his farm and obtained good water.

In brief, there would appear to be a functional connection between technological uncertainty in locating wells in this arid environment with a complicated geological structure and the flourishing of the water-witching pattern. This conclusion is fortified by the observed fact that the area of highest anxiety in the community—the location and development of adequate water resources—is also the area of the most persistent and most utilized ritual pattern—the water-witching technique (57 per cent of the observed instances of ritual practice)—and by the fact that water witching, which is an unused skill in the ancestral region of the Texas Panhandle, was activated and has flourished in Homestead.

Thus, although a relationship can be demonstrated between technological uncertainty and ritual in the case of water witching, the pattern has been elaborated and rationalized in terms of one of the central value-orientations of Homestead. For in their relationships with the natural environment the homesteaders strongly emphasize an orientation which may be described as "rational

*** Mr. Meeks has called my attention to the fact that the Soil Conservation Service maintains only two geologists in the Southwest who give advice on locating wells; hence their visits to any given community are necessarily infrequent.

mastery over nature;"[28] the environment is viewed as something to be controlled and exploited for man's material comfort. And for the adherents of water witching in the community, the pattern becomes an important expression of this value stress upon "rational" environmental control. It is part of the farming process—along with clearing the land with bulldozers, plowing, planting, and cultivating the fields with power machinery—to locate a well by witching before one employs a driller. Explanations of how dowsing works are predominantly sought in terms of "electricity" and other "scientific" concepts. Rationalization for errors is provided in terms of the presence of metal objects which "short-circuit" the process, or in terms of technologically faulty equipment.

There are clearly certain functional "gains" in the practice of water witching for the development and continuing survival of a community like Homestead. The *certain* answers provided by the dowser relieve the farmers' anxiety about ground water resources and inspire confidence to go ahead with the hard work of developing farms. The pattern also provides a cognitive orientation to the problem of why water is found (at a certain depth) on one farm and not on another—in terms of the ideas about water veins that run irregularly under the ground.

But it is equally clear that the practice of dowsing involves certain functional "costs" in this situation. Energy and resources are invested in a technique which does not provide any better information as to the location of shallow underground water supplies than does the good judgment of individual farmers. It is also often the case that dowsed wells will be located at spots that are highly inconvenient and inefficient for the most economical operation of the farm. Some farmhouses in the community have been built in inaccessible places on the sides of hills "because that is where the water witch found the water." But the homesteaders who are adherents of dowsing believe that they are being "scientific" about locating underground water. These attitudes detract from the effort of obtaining more precise geological information which, even if it does not tell the farmer in terms of so many feet how far it is to water at a given location, is at least a more promising long-range approach to the development of water resources for the community.

Some Comparative Data

Homestead is located in a region inhabited by four other cultural groups: Mormon, Spanish-American, Zuni, and Navaho. The water-witching pattern is part of the cultural equipment of the Mormons and the Spanish-Americans, but it is generally absent among the Navahos and Zunis. The Mormon experience with water dowsing parallels that of Homestead. The Mormon community is located in a well-watered valley at the base of a mountain range. In this valley wells can be drilled at almost any location, and ample ground water obtained at 30–40 feet. Some of the Mormon settlers have dry-land farms and ranches in the area to the south and east in which the ground water situation, with a high degree of variability in amount and depth, is comparable to that of Homestead. Although the Mormon community has a water witch, he has dowsed only five wells in the irrigated valley during the past forty years. On the other hand, he has been employed to witch more than fifty wells in the dry-land farming and ranching region where the ground water situation is highly uncertain. Occasionally, the Mormon water witch is employed to dowse for the homesteaders, and the water witch from Homestead has been employed on at least three occasions to dowse for the Mormons.

Water witching is also used by the Spanish-Americans in the area. About fifty years ago there was a practicing Spanish-American dowser, but at present the Spanish-American population does not have its own dowser. Instead, water witches from Homestead or the Mormon community dowse wells.

So far as we can determine, the water-witching pattern is unknown to the Zunis and to most Navahos, and there is no evidence that aboriginal divining techniques—such as Navaho hand-trembling—have ever been used to locate springs or wells. The only exception in the Navaho community is found in the case of three older Navahos who in the 1930s observed the techniques of the Mormon water witch. When the Navahos tried the technique themselves, the witching stick "worked" for only one of the three. This Navaho still claims to be a water witch and reports that he has (on his own initiative) dowsed three wells, two of which produced water, and one of which was a dry hole. The powers of this one Navaho water witch are not generally recognized by others in the Navaho community, and, indeed, he is usually ridiculed when he talks about dowsing. It should be noted that this dowser is the only one of the local Navahos who has become an earnest convert to Mormonism; he is now an elder in the Mormon church.

The general absence of the pattern among the Zunis and Navahos is partly a matter of history, in that it was not a part of the cultural tradition

of these groups as it was in the case of the homesteaders, Mormons, and Spanish-Americans. But it is also partly a matter of geographical situation and the use made of water resources by the Indians. Before the Indian Service began to drill wells for these two tribes, the Navahos depended upon springs, natural water holes, and lakes for water; the Zunis depended upon springs, natural lakes, and the Zuni River. Although both tribes now have wells on their reservations, the problem of locating and drilling the wells is completely in the hands of Indian Service technicians.

There is one interesting case of a highly acculturated Navaho who decided to have his own well drilled. At the suggestion of the Mormon trader, he employed the Mormon water witch and paid him $25 to locate a well. The dowser designated a location with his witching stick and told the Navaho that it would be 12 feet to water. A well driller was then employed, but the only result was a dry hole 400 feet deep which cost the Navaho $1200. The Mormon trader commented, "First time I've seen the water witch miss;" the water witch explained the situation by asserting that "the vein must have dried up," since it was several months after the dowsing took place that the well was drilled. The Navaho is thoroughly disillusioned about the powers of water-diviners.

Our conclusion is that water witching is a ritual pattern which fills the gap between sound rational-technological techniques for coping with the ground water problem and the type of control which rural American farmers feel the need to achieve. The best geological knowledge of ground water resources that is currently available still leaves an area of uncertainty in the task of predicting the exact depth to water at a *given* location in a region with a variable ground water table. The water-witching pattern provides a reassuring mode of response in this uncertain situation.

Thus, although water witching is to be regarded by the scientific observer as a nonempirical means for achieving empirical ends—and is functionally equivalent to the magical practices of nonliterate societies—it is generally viewed as a rational-technological procedure by its adherents in rural communities. The technique can, therefore, best be described as a type of "folk science" or "pseudo science" in the rural American cultural tradition. As a body of pseudo-scientific knowledge, the water-witching pattern in our rural farming culture is the same order of phenomena as the pseudo-scientific practices that cluster around situations of uncertainty in other areas of our culture; as, for example, in modern medical practice where there appears to be a pattern of "fashion change" in the use of certain drugs, an irrational "bias" in favor of active surgical intervention in doubtful cases, and a general "optimistic bias" in favor of the soundness of ideas and efficacy of procedures which bolsters self-confidence in uncertain situations.[29]

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SCIENCE ON THE MARCH

THE AMERICAN EXPLOSION

ONCE in a great while the tempo of progress quickens. A society explodes in a flood of new ideas, new tastes, new standards. A fresh and exciting age emerges, marked by changed attitudes, changed customs, changed goals—and alive with expanded opportunities for those who first recognize the new signposts and have the courage to follow them.

Today's Americans are living in one of these extraordinary periods of human history. The culture and the economy of the United States have, in less than a generation, exploded into an entirely new dimension. Only the nagging threats of war, and preoccupation with daily headlines, could have kept so many Americans from realizing what has happened. The atomic burst was only a part of the American explosion. World historians will still be talking about the age of the American Explosion when Los Alamos may be as little remembered as the spot where man first learned to light a fire.

None of these great surges is accidental. The Golden Age of Pericles didn't just happen. It sprang solidly from the deep-seated roots and accumulated experience of a people. The sudden flowering of Greek culture was as logical as the overnight flowering of a mature plant.

The American Explosion didn't just happen, either. It was three hundred years in the making. The energy and the experience of the hundreds of millions of free people who have lived and worked in what is now called the United States had accumulated in the enormous time-bomb that finally burst in this last decade. It is the net result of a heritage of adventurous curiosity, free democracy, and inventive ingenuity.

The statistics of this change are all around us—and are exciting in themselves. But even more significant, and less easily recognized, is the new pattern that has emerged—the intricate set of tangibles and intangibles that make today's Americans different, as people, as consumers, as participants in an age of new-world maturity.

In this pattern can be found the sharp difference between this and any other golden age in recorded history. It is neither the product nor the property of any particular class. The average *individual* American not only had a full share in setting off the fuse, but he shares fully the advantages and opportunities that the American Explosion has left in its wake.

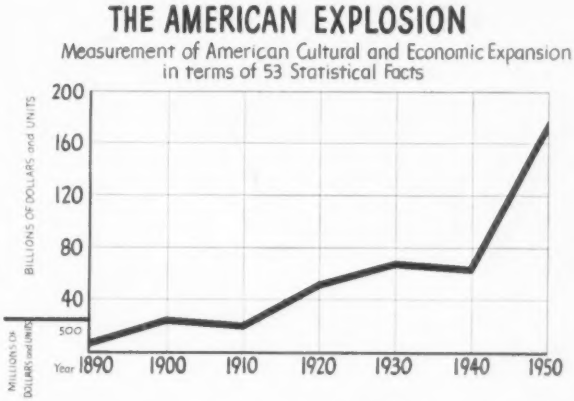

FIG. 1. Statistics are based on facts and sources listed in Table 1 and in the references at end of article.

It is to this individual American to whom we must look, therefore, for an understanding of the new economy. By way of a thought-starter, let's look quickly at a few facts that suggest how sharply he differs from his pre-Explosion relatives (Table 1 and Fig. 1):

1. Americans spent more dollars to go to classical music concerts than to baseball games last year,[1] and 96 per cent more constant dollars for books than they did a decade before.[2]

2. Americans increased their annual use of electric energy more between 1940 and 1950 than in the entire previous time since electric power has been installed in America.[3]

3. The average American's real purchasing power was 53 per cent greater in 1950 than in 1940;[4] after adjustment for the rise in living costs, the average workingman's real wages were 35 per cent higher last year than in 1938.[5]

4. In the decade 1940–50, 141 million people have moved from one part of the country to another,[6] from farms to industrial centers, from one house to another.

5. The average family diet improved sufficiently to help produce children 2–3 inches taller than children of the same age 50 years ago.[7] This food cost the breadwinner less than half the percentage of his income he spent in 1900.[7]

6. Forty-five per cent more Americans graduated from colleges in 1948 than in 1940.[8]

7. In America today, for the first time in history, more consumers (54 per cent) own their own homes than pay rent.[9]

TABLE 1

FACTORS IN THE "AMERICAN EXPLOSION"

	Period	Original Date		Actual Increase
Improved taste				
Number of local opera companies	1941–51	2– 13		11
Personal expenditures for				
Musical instruments, phonographs, records, radios, and television sets	1940–50	$507,000,000–	$2,848,000,000	$2,341,000,000
Photo developing and printing	1940–50	21,000,000–	102,000,000	81,000,000
Toys and sports equipment	1940–50	519,000,000–	1,797,000,000	1,278,000,000
Flowers and seeds	1940–51	211,000,000–	689,000,000	478,000,000
Legitimate theatre and opera	1940–50	$36,000,000–	$90,000,000	$54,000,000
Number of classical musical concerts held out of New York City	1940–51	3,700–8,500		4,800
Visits to national parks and forests	1940–49	16,755,251–31,864,180		15,108,929
Number of towns now providing regular classical music concerts	1941–51	1,000–2,100		1,100
Number of persons attending concerts of classical music	1941–51	16,000,000–30,000,000		14,000,000
Number of symphony orchestras	1940–51	111–200		89
Educational progress				
Personal expenditures for				
Private commercial and trade schools	1940–50	$24,000,000–	$134,000,000	$ 110,000,000
Private elementary, secondary, and higher education, and research	1940–50	475,000,000–	1,355,000,000	880,000,000
Economic advance				
Production of electric energy (kwhr)	1910–40	20,499,775,000–	179,906,954,000	159,407,179,000
	1940–50	179,906,954,000–	387,924,000,000	208,017,046,000
Production of petroleum (bbls.)	1880–1924	26,286,000–	713,940,000	687,654,000
	1940–50	1,353,214,000–	2,042,686,000	689,472,000
Gross farm income	1910–40	7,352,000,000–	11,010,000,000	3,658,000,000
	1940–50	11,010,000,000–	32,055,000,000	21,045,000,000
Value of farm implements and machinery	1910–40	1,265,000,000–	3,060,000,000	1,795,000,000
	1940–50	$3,060,000,000–	$14,208,000,000	$11,148,000,000
Number of tractors on farms	1910–40	1,000–	1,545,000	1,544,000
	1940–50	1,545,000–	3,825,000	2,280,000
Value of foreign trade exports	1880–1940	$852,782,000–	$4,029,815,000	$3,177,033,000
	1940–50	$4,029,815,000–	$10,274,782,000	$6,244,967,000
Number of American families in the $5000-plus income bracket	1940–50	1,428,000–	5,719,000	4,291,000
Personal expenditures for furniture and furnishings	1939–51	$1,199,800–	$5,429,000	$4,229,200
Improved communications				
Personal expenditures for newspapers and magazines	1940–50	581,000,000–	1,350,000,000	769,000,000
Foreign exposures				
Foreign travel fares (steamship and overseas aircraft)	1940–50	13,000,000–	107,000,000	94,000,000
Medical advance				
Personal expenditures for				
Group memberships in hospitalization plans	1940–50	16,000,000–	145,000,000	129,000,000
Accident and health insurance	1940–50	126,000,000–	447,000,000	321,000,000
Private hospitalization	1940–50	$527,000,000–	$1,955,000,000	$1,428,000,000
Increase in Children's average height	1900–50			2–3 in.

8. In a steel plant, it takes 5 hours to anneal a ton of strip steel—instead of 120;[13] in a textile plant, an electronic device checks dye color in 2½ minutes—instead of 1½ hours.[13]

9. In the 1940–50 decade, the output of petroleum increased more than it had since the discovery of oil.[11]

10. In 1947, 38 per cent more factories employing 52 per cent more workers turned out a dollar volume of goods three times as high as in 1939.[12]

11. More Bibles were purchased between 1941 and 1951 than were bought in the previous 40 years.[10]

These are some of the elements of the new pattern left in the wake of the great American Ex-

plosion. It is not a pattern made by a people interested only in material progress—"in bread alone." It is, rather, a design that shows a well-rounded people, matching material progress with the building of a great new national culture that has borrowed from—and has something to lend to—the world's older cultures. In a further examination of these facts, and others, the pattern becomes clear—a picture of an entirely new kind of America, and Americans, whose new behavior, desires, needs, and tastes demand new patterns of service and distribution.

This new consumer is usually distinguished from his predecessors on a purely economic basis—so much more income, so many more dollars in the bank, and so many more possessions. The figures are true enough—but they tend to obscure the more significant results of the cultural revolution of the past decade—and to hide the fact that today's progress is solidly based on the stored-up experience and labor of 200 years. This can only be understood when it is realized that the customs, attitudes, and habits of today's American have changed even more drastically than the state of his pocketbook.

The picture of the average American as a highway-happy worshiper of a shiny new automobile is sadly out of date; Americans are still buying motor cars, but only at a modest 10 per cent greater rate than a decade ago.[14] By contrast, in 1950 compared with 1940, Americans spent 96 per cent more constant dollars for books,[2] 140 per cent more for toys and sports equipment,[2] 219 per cent more for photo developing and printing,[2] 129 per cent more for flowers and seeds,[2] and 263 per cent more for phonographs and records, musical instruments, radios, and television sets.[2] Personal expenditures (in constant dollars) for the legitimate theatre and the opera are up 85 per cent in the ten-year period[2] in comparison with only 42 per cent for motion pictures.[2] These figures begin to sketch a picture of a book-reading, garden-tilling, sports-loving American, who likes music and takes time for hobbies.

There is much to support the fact that the taste of the average American has sharply improved during the great explosion. It is estimated that 130 per cent more classical music concerts were held out of New York City in 1950, as compared with 1940.[15] Today, sales of classical records account for 40 per cent of the total of all record sales—as against 30 per cent in the prewar period.[16] Attendance at concerts of serious music jumped 88 per cent between 1941 and 1951.[17] The last decade saw an increase of 80 per cent in the number of symphony orchestras[17] and of 550 per cent in the number of local opera companies.[17] Twice as many towns—more than 2000—now provide serious music regularly for their populations.[17]

Admittedly, improved taste is more than a matter of an acquired preference for classical music. But plenty of other changes have taken place. Today's workingman and -woman have discovered that graceful living is far from inconsistent with productive labor. Homeowners spent three times as much for home decoration in 1948 as they did in 1939.[18] In constant dollars, furniture and furnishing store customers paid out 200 per cent more in 1951 than they did in 1937.[18] There are 50 per cent more successful home service magazines published today than there were in 1940[19]—and their circulation has climbed from 2.3 millions to more than 3.5 millions.[18] The quality of wallpaper design, of draperies and upholstery, of the very pictures on the walls, in today's modest homes trumpets a revolution in American taste.

The change is also visible along any Main Street—from Sioux City to Bronxville. Fashionable apparel is no longer the exclusive property of *Vogue* and *Harper's Bazaar* readers. The rise of the business girl's fashion magazines—*Mademoiselle, Glamour, Charm,* and the like—testifies to the fact that high-fashion clothing is available on almost any budget. The mass-production techniques of manufacturers like the fabulous Henry Rosenfeld have made it worth while for the stenographer and shopgirl to learn how to dress as well as does the Westchester matron. Today's Colonel's lady and Mollie O'Grady are sisters over the skin as well as under it.

This rapid recital of figures and percentages, however necessary, runs the risk of leaving the impression that this great surge happened in a vacuum—or was the result of some political or economic planner's dream. Nothing could be further from the truth. The fuse of the time-bomb that has exploded in the last decade was lighted in America's past. The Ben Franklins, Thomas Jeffersons, Roger Williams, John Marshalls, and the hundreds of others who contributed to the establishment of the American idea were really responsible for today's sharp spurt of progress.

Franklin and Jefferson would be pleased to note that the United States is changing from the most to the least provincial country in the world. Today's maturing American is further broadening his outlook by exchanging experiences and ideas with other Americans and men and women of other countries. Americans are moving from place to

place within the nation's boundaries; their high rate of migration spells the rapid end of well-defined regional differences. Further, Americans are becoming a better integrated people through increased use of mass-communication devices. Unit sales of books are up 60 per cent in the decade.[20] Expenditures for newspapers and magazines take almost 76 per cent more constant dollars.[2] More than 10 million homes already have television sets —with which to see for themselves how the rest of the country lives, dresses, acts, and thinks.[18]

Foreign exposure rounds out the picture. The American Main-Streeter no longer looks toward the rest of the world with a strange and faintly suspicious eye. He is ready and willing to appreciate and adopt foreign inventions and ideas, as well as able and willing to export some of his own. Foreign travel itself has moved from the realm of the idle rich to that of the vacationing stenographer. Americans spent 412 per cent more for steamship and overseas aircraft fares in 1950 than they did in 1940 (in constant dollars).[2] There were 55 per cent more overseas travelers (1950 over 1937),[21] spending 67 per cent more dollars in foreign countries.[22]

A heightened urge for education certainly contributes to this increase in travel that took almost 100 per cent more Americans to our own national parks and shrines in 1949 than in 1940.[23] There are many other evidences that the little red schoolhouse is no longer looked upon as something to be got through as rapidly as possible. In 1951, the year after the GI surge subsided, 23 per cent more Americans were enrolled in institutions of higher learning than in 1940.[24] In constant dollars, Americans were spending 104 per cent more for higher education and elementary and secondary schools[2] and 261 per cent more for commercial and trade schools.[2] Increased participation in adult education programs was equally heavy. Americans are using education as a tool with which to make their lives fuller and more productive.

These suddenly awakened cultural interests have come hand in hand with an increased physical vitality. Americans have discovered—in modern medicine, nutrition, and in living habits—the key to longer life, greater vigor, and an extended productive span. Medical discoveries have added 9 to 12 years to life expectancy in the last generation.[18] The average life expectancy for Americans stands today at a high of 68 years;[25] at the turn of the century, it was only 47 years.[25] In constant dollars, Americans spent 94 per cent more for medical care,[2] paid 154 per cent more to private hospitals,[2] laid out 460 per cent more in payments to group hospitalization associations,[2] and paid 159 per cent more for accident and health insurance in 1950 than in 1940.[2]

The average working family's improved diet, bought with half the percentage of the income spent in 1900, has produced children 2 to 3 inches taller than they would have been at the same age 50 years ago.[7] The change in the dimensions of the bathing suit is graphic evidence of the new outlook toward sun, fresh air, and exercise. Today's Americans can live and work longer, and live and work harder. They also (for the particular attention of marketing men) have a considerably longer active buying period.

Hand in hand with this almost unbelievable ten-year surge in spiritual, cultural, and physical progress, has come a considerable improvement in the average American consumer's economic status. The individual American has made the Horatio Alger story come true—not in the rags-to-riches sense, but in his apparently limitless opportunity to improve his individual living standard by producing more. The statistics resulting from this feat—in terms of individual income, gross national product, individual savings, and the like—are well known and hardly need repetition here. A few figures are enough. The real purchasing power of the American consumer was 53 per cent greater in 1950 than in 1940.[4] Three hundred per cent more Americans are in the $5000-plus income bracket,[26] and 57 per cent fewer in the $1000-minus area.[26] Assets of life insurance companies increased 49 per cent (in constant dollars) in the last decade,[27] and electric energy output—a good measure of over-all growth in an electrical age—climbed 4400 per cent in the past twenty years![28] American farms acquired about 1,500,000 tractors between 1910 and 1940;[29] in the ten-year explosion period almost 2,300,000 were added.[29]

These exciting economic statistics lead to the popular habit of reducing the difference between America, 1940, and America, 1950, to the fact that "people have more money." Here, cause and effect are reversed. The rise in the American national income is a result of the great explosion—not its cause, or even its most significant effect. Just money cannot be used to explain away the brilliant advances of the explosion decade—advances like the addition of antibiotics to our medical lore, the development of nylon and the other, newer synthetic fibers, and the discovery and harnessing of atomic energy. These products of inquisitive minds are the basic impulse for our prosperity, the *source* of our new money.

In the understanding of this relationship lies the key to intelligent business adjustment to the new customer. The pat "people-have-more-money" answer to the American phenomenon leads to equally pat marketing theories—and obscures the more valid and the needed changes in distribution techniques.

If the great change that has taken place in America during the past decade were merely a matter of money, all that industry would need to do would be to produce more and sell more. Unfortunately, it is not that simple. Companies that follow such a course run the risk of turning out large numbers of copies of *September Morn* for a public that has learned to prefer Van Gogh—or of producing Mission furniture for couples who want Swedish modern—or of grinding out ten-year-old-mind movies for an America that has matured! The same fate awaits companies that fail to recognize the new ways of living, the new buying habits, the new goals and aspirations that characterize the post-explosion American.

The explosive elements in the American character that combined to produce this new Golden Age cannot be measured like a pound of nitroglycerine—or even like a statistical concept such as the size of the gross national product. Only application of the science of people can explain why the average American thinks and acts as he does—and how he has accomplished so much so suddenly:

1. Americans have captured the extraordinary vitality which science has proved is typical of the first few generations of a people of mixed blood strains. The constant infusion of new peoples—all adventurous and courageous enough to venture to a new world—has kept America's energy quotient high.

2. Americans have been—and are—open-minded enough to accept change in their stride. Here, in contrast to most of the world, new ideas must batter through only a relatively thin layer of tradition.

3. Americans have been able to combine intelligent cooperation with vigorous individualism. Americans have not accepted the need for "cooperation" as a reason for abridgment of individual freedoms. On the other hand, they have refused to allow their individualism to keep them from reaping such benefits as industrial standardization and orderly political cooperation.

4. American ingenuity and curiosity have put ideas to work for a better standard of living. This kind of American "materialism" has had much to do with creating the necessary climate for the explosion.

The American Explosion, then, was prepared in this Yankee environment of vitality, open-mindedness, individualism, cooperation, and ingenuity. When the horny-handed pioneer built his red schoolhouses and steepled churches he was investing in the strength and greatness of individual Americans who were to come after him. Now his magnificent conviction has left a new kind of American—and a new kind of American consumer—in its wake. Every American business serving the consumer must reckon with this new American—and the explosion that he made happen.

FENTON B. TURCK

Turck, Hill & Company, Inc.
10 Rockefeller Plaza, New York

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BOOK REVIEWS

BIRDS—JUST BIRDS

American Bird Songs, Vol. II. Recorded by P. P. Kellogg and A. A. Allen for the Albert R. Brand Bird Song Foundation, Laboratory of Ornithology, Cornell University. Five 12-inch Vinylite records (51 recordings). $10.50. Comstock, Ithaca, N. Y. 1951.

ONE of the most famous dicta in science, and especially in natural history, is Louis Agassiz' "Study nature, not books." One might be tempted to transfer this admonition to the study of bird songs—that they should be heard and learned in nature, not from albums of phonograph records.

Louis Agassiz himself provided the conclusive proof that his advice was so one-sided as to be essentially fallacious, for the first extensive bibliography of zoological literature was compiled by him. It was published by the Ray Society in four fat volumes (1848–54) under the title *Bibliographia Zoologiae.* It is thus perfectly evident that Agassiz himself studied both books and nature, and that the really sound advice is to study nature in the light of books and books in the light of nature.

This is precisely the merit of the records of *American Bird Songs,* of which the second album, as Volume II, is now available. One may go from recording to the field and refresh one's field memories by the recordings. If the recordings will stimulate more critical attention to bird voices, and to their individual and regional variation, they will serve a genuinely scientific function. The fact that the bird voices on records are in themselves delightful, especially in the framework of one's audile imagination and memory, is an additional pleasure that may be shared by bird-lover scientists and by unscientific bird-lovers.

The quality of the recordings in the second album is notably improved over the first. Some of the voices most faithfully captured are triumphs of ornithological field work. One may hear in one's living room the wild notes of the loon and the limpkin, the familiar voices of bluebird and house wren, a notable series of the little-known warbler songs and notes, and—of greatest interest—a dozen voices of marsh and water birds. Some of these are known merely as disembodied voices by the hunters and fishermen and farmers' boys and naturalists who frequent their haunts. Such native Americans as the "slough pumper" (bittern), the grebes, the coot, the sandhill crane, the rails, and the snipe will not often be heard by most of us; thus they are the more worth hearing on these records. We owe a real debt of gratitude to Drs. Kellogg and Allen for their preparation of this notable addition to the first album of bird voices and to their equally fine album of frog voices, *Voices of the Night.*

KARL P. SCHMIDT

Department of Zoology
Chicago Natural History Museum

Stalking Birds with Color Camera. Arthur A. Allen. viii + 328 pp. Illus. $7.50 in U. S. and Possessions; $7.75 elsewhere. National Geographic Society, Washington, D. C. 1951.

ABOVE all, this book is a work of art! It is an achievement not only of its author, but of the National Geographic Society and the technical skill of the photographic and printing industries

Dr. Allen began taking pictures of birds in 1904, and in this book we see the fulfillment of an early ambition "to capture the charm of birds in action in living color." This is the first book of its kind to be illustrated profusely with natural color photographs. Of the 331 color illustrations, 264 were made by Dr. Allen. In all, they portray 266 North American species in their natural habitats.

The book contains thirteen chapters, each of which tells a different story. Some explain the techniques, problems, and rewards of photographing birds in color and recording their songs; others take the reader on expeditions to timberline and tundra around Hudson Bay, to Labrador, to Alaska in search of the curlew's nest, to Mexico, and to various parts of the United States. Each chapter is profusely and beautifully illustrated and is replete with firsthand observations of birds, many of them made at arm's length from the nest. A most remarkable chapter, Freezing the Flight of Hummingbirds, was contributed by Edgerton, Niedrach, and Van Riper. Dr. Edgerton was responsible for designing the speed-flash equipment that made these amazing photographs possible. He also supplied Dr. Allen with improved speed-flash equipment, which enabled him to take some truly remarkable color photographs of birds in action. Most of the color plates and articles first appeared in the *National Geographic Magazine,* which assumed the original cost of publication. Preparation of the illustrations exclusively for this book would have made the price prohibitive. Nevertheless, the book includes 72 new color plates. A great deal of care obviously went into checking the accuracy of color reproductions, into the composition of each photograph and color plate, and into the design of the book as a whole. To this reviewer, the illustrations in natural color are much more than mere photographs. They are compositions of nature's beauty, with birds as the central figures. Unlike the finest paintings of birds, they convey a definite realism and a feeling that one is actually observing the bird. Hence they do more than illustrate; they give one an acquaintance with each species. The speed-flash photographs, taken at 1/5000 of a second and in color, are, without exception, the finest portraits of birds available. One can count the feathers in the wings of the hummingbirds; and by means of a multiple exposure one can see a hummingbird fly back-

wards! The day should not be too far distant when natural color photographs will replace completely the artist-drawn color plates in our state books of birds. Dr. Allen has truly fulfilled his desire of capturing the charm of birds.

The National Geographic Society must be congratulated for making this magnificent collection of photographs available, not only by publishing them at a nominal price, but by its encouragement and financial support of Allen, Edgerton, and their colleagues.

This book is strongly recommended to those who enjoy birds, to those who enjoy nature's form and color, and to those who get satisfaction from seeing the achievements of man's technical skill.

ALBERT WOLFSON
Department of Biological Sciences
Northwestern University

Grønlands Fugle (*"The Birds of Greenland"*), Part II. Finn Salomonsen, with color plates by Gitz-Johansen. Pp. 159–348, 19 colored plates. $9.00. Ejnar Munksgaard, Copenhagen. 1951.

PART II of *The Birds of Greenland* contains a discussion and illustrations of the ptarmigan, plovers, sandpipers, phalaropes, jaegers, gulls, and terns—25 species altogether. There is no table of contents, map, or index in this volume, and the two-column format continues the same as in Part I, with the Danish text on the left and the English at the right. (The English is not claimed to be an exact translation of the Danish.) The book measures 9 × 13 inches and is printed in pleasing type on heavy mat paper with wide margins.

The full-color plates give one the feeling of the birds in their Greenland habitat, but are rather sketchily done, compared to those by Weber, Sutton, Peterson, or Dilger that we are accustomed to finding in an American bird book.

The text continues, in the excellent quality of Volume I, to give, from the author's experience and his review of the literature, as complete information as possible on each species, as to its occurrence in Greenland, its taxonomy, plumage, breeding habits, migratory routes, food, etc. In order to follow the author's discussion of the distribution in Greenland, the reviewer hopes a good map will be printed in the last volume (No. III), because so many of the locality names are unfamiliar.

The account of each species is preceded by a small sketch of the bird and its name in Danish, English, and Eskimo, as well as its current scientific name. Ornithologists everywhere will welcome this authoritative addition to the study of local faunas, and extend their appreciation to the Danish government for supporting such a worthy publication.

ARTHUR A. ALLEN
Laboratory of Ornithology
Cornell University

SCIENTIST WITH A SOCIAL CONSCIENCE

Cottrell: Samaritan of Science. Frank Cameron. 414 pp. $4.50. Doubleday, New York. 1952.

THOUGH poorly subtitled, as anyone who has read the tenth chapter of Luke will agree, this book is a very interesting one and, for the most part, well written.

The author has done his subject a disfavor in one respect. The reader is given a strong impression that Cottrell felt unnaturally bitter toward his mother. Perhaps there was reason for this. If so, it is poorly explained, and the stature of the subject is reduced as a result.

If known at all to the average layman, the name of Cottrell is vaguely associated with some sort of device for smoke elimination. This, of course, is a fate suffered by the majority in scientific work. It is unfortunate that Cottrell is not better known, because he was much more than a great scientist and inventor. And great scientist he was, in spite of the contrary opinion of some of his contemporaries.

Cameron's book is entertaining and easily read and can be recommended to any lay reader. If it does reach this type of audience it will serve to make Cottrell much better known than he is, but it will probably be read for the most part only by the scientifically minded, who are already acquainted with its subject.

In addition to his great abilities as a scientist and inventor, Cottrell possessed a social consciousness not ordinarily associated with men of this type. His conception of the idea of the Research Corporation and the years he spent in guiding and nurturing it are a far greater accomplishment than his invention of the Cottrell precipitator, even though the funds derived from the latter made the former possible.

Cottrell could be considered prescient, judging by some of his statements. For example:

> There is a certain amount of intellectual by-products going to waste at present in our colleges and technical laboratories all over the country. There is a great deal of work that is being developed to a practical or semi-practical standpoint that dies right there because the men . . . do not want to dip into the business side of technology and go out into practical fields, and the work has not come to the point of economic usefulness that is desired.

This remark was made in 1911, over forty years ago. It is true today, with a few bright exceptions which have resulted from formation of organizations of technical men, by technical men and for technical men, such as the National Research Corporation and the American Research and Development Corporation.

Similarly, his ideas of internationalism, although vague in some respects, were far in advance of the thinking of his contemporaries when he first began to formulate them in 1912, and they remained ahead as the years passed. His belief, expressed in 1920, that "international co-operation in both pure and applied science could unquestionably furnish one of the most

powerful forces possible against the growth of national misunderstandings" is still true.

But how much more true today than when uttered in 1932 is his statement that

> . . . we are today far over-specialized. . . . The specialist working in any particular field must become more willing to work over the boundary line of the next adjacent field and encourage the workers there to do the same for his. It is only by this cooperative interlacing of knowledge, sympathy and experience . . . that we can get the full benefit of the most intelligent human endeavor in the present age.

Truly, Cottrell had such breadth of vision as one wishes were possessed by our leading scientists today!

RALPH F. WOLF

Akron, Ohio

CRITIQUE OF AMERICAN BUSINESS

Business Be Damned. Elijah Jordan. xiv + 267 pp. $4.00. Schuman, New York. 1952.

THROUGHOUT the history of their calling, moral philosophers have uttered outraged cries against the adroit manipulators of social power and against mass man for permitting others than moral philosophers to influence him. What Elijah, Plato, Savonarola, and many another prophet and theorist did before him, Jordan again attempts to do in terms of the present scene. And, like so many speculative philosophers, he does not see himself in any adequate historical perspective or show acquaintance with social scientific findings.

Jordan states his case rather simply at the outset. Business has come into "undisputed power in the affairs of the modern world." This "has been made possible by the almost universal acceptance of certain assumptions." He therefore takes it as his assignment to demonstrate "the falsity of these assumptions and to show what have been their more important consequences."

When a social scientist learns that certain assumptions or other ideas have "almost universal acceptance," he realizes that he confronts social data of significance and stability that require careful study and assessment. Little understanding can be gained by starting out to prove that "everyone is out of step but me."

Jordan attacks especially the "major assumption . . . that the practical man is the intelligent man." Actually the question as stated is not an important one, but surely Jordan has heard that there are different types of intelligence, not merely the kind that gets prize students into Phi Beta Kappa.

Careful criticisms of business, businessmen, and specific business practices are essential, especially in a time when a hush-hush policy has prevented much critical discussion of power-wielders. But one must be uninformed to say that it is "the moral irresponsibility of business" that is transforming Christian civilization "into the noisome bedlam we see today in a collapsed industry, a dilapidated government, a prostrate church, a supine and spineless and empty education."

What is Jordan's solution for his problem? This, too, is all so simple. Where Plato wanted the power-wielders of his day, the kings, to become philosophers or the philosophers to rise to kingships, Jordan wants businessmen to become Professors or Knowers of Exchange and Distribution. Such a person would be

> . . . characteristically a moral agent, where his old enemy the businessman was a moral pervert. Civilization and culture can be made fruitful in and of all the values when his intelligence prevails. The creators and guardians of the essential types of values have been restored to their rightful functions. They assume once more the guidance of the destinies of mankind. The Minister, the Teacher, the Lawyer, the Statesman, the Physician, the Artist, all now cleansed of the Great Contamination, approach and join hands with the Merchant. The New Man steps forth upon the New Earth.

Jordan's series of essays is amusing as poetry.

ALFRED MCCLUNG LEE

Department of Sociology and Anthropology
Brooklyn College

BRIEFLY REVIEWED

Patterns of Survival. An Anatomy of Life. (2nd ed.) John Hodgdon Bradley. 223 pp. $3.75. Grune & Stratton, New York. 1952.

IT IS indeed encouraging that a book of this caliber reaches its second edition; the first appeared in 1938 with Macmillan. Bradley presents in a tightly written and often poetic style a thoughtful review of general biology, from the viewpoint of a paleontologist. It is a text without an illustration, a footnote, a bibliography, or an index. Its charm is in compact expression, freshness of simile, wealth of allusion, and thoughts based on the facts rather than the concepts these have accumulated. For complete understanding of the contents the reader will need a wide acquaintance with the fossil record, with plants and animals. His mind will be directed to the unknowns and the probabilities, to problems that continue such in spite of a wealth of attractive but inadequate hypotheses to explain the observed details. The author gives attention to the origin of life, to the long delay in reaching fossilizable form after the earth appeared ready for it, to the endless interplay of progress and degeneration, of active and passive lives, and of the essential similarities between living things, as well as the differences in design that separate them into classified groups. Those who clamor for a book on biology dealing primarily with principles and scantily with terminology and detail have it in *Patterns of Survival.* We expect to recommend it highly to mature scientists—particularly biologists, psychologists, and sociologists—and to their equivalent among the thoughtful laity. But we shall be surprised if a college freshman finds in its few pages the impetus for a glowing book report or term paper.

LORUS J. and MARGERY J. MILNE

Department of Zoology
University of New Hampshire

The Scientific Papers of James Clerk Maxwell. Two volumes bound as one. Complete and unabridged from the definitive edition of 1890. W. D. Niven, Ed. 1488 pp. + 14 plates. $10.00. Dover Publications, New York. 1952.

DOVER has now made available in one volume Maxwell's scientific papers. Besides some of the famous papers on the theory of color, the dynamical theory of gases, the theory of optical instruments, the physical lines of force, and the dynamical theory of the magnetic field for the advanced student, there are a number of papers of a semipopular nature: there are the addresses delivered before the British Association for the Advancement of Science, articles that Maxwell contributed to the *Encyclopaedia Britannica,* lectures of a biographical nature published in *Nature,* and his book reviews, all of which are just as interesting today as the day they were written. The address to the British Association in 1870 on the relation of mathematics and physics (Vol. II, p. 215), or the one on color vision at different points on the retina, or the one on molecules, his introductory lecture on experimental physics, the discourse on action at a distance (an evening lecture at the Royal Institution), the article "Atom" (Encyclopaedia Britannica), the article on capillary action, his lecture on the telephone—to name only a few —are masterpieces of science teaching, and both teachers and students will profit by studying these classical essays in detail.

KARL LARK-HOROVITZ

Department of Physics
Purdue University

My Fight to Conquer Multiple Sclerosis. Hinton D. Jonez. xi + 227 pp. $3.50. Messner, New York. 1952.

THIS is an account of the growth of the multiple sclerosis clinic in Tacoma, Washington, of experimental determinations of most effective dosage with histamine, curare, balanced sex hormones, and other drugs, based on the belief that demyelination is an allergic response. Jonez relates incidence of the illness to protein intake and cereal and milk diets, and attempts to identify individual allergens and eliminate them as a first step in treatment. His successes will encourage those with a diagnosis of multiple sclerosis.

MARGERY J. MILNE

Department of Zoology
University of New Hampshire

Advanced Calculus. Wilfred Kaplan. xiii + 679 pp. Illus. $8.50. Addison-Wesley Press, Cambridge, Mass. 1952.

THIS book offers all one could wish for in a text in advanced calculus. It is clearly written, rigorous, and comprehensive. The material is selected so as to make the text serve well for a course designed for engineers as well as for students of pure mathematics. The author presents vector analysis early in the book and uses the vector methods to give a clear treatment of the differential and integral calculus in space. The chapter on infinite series is followed by a nice introduction to the theory of Fourier series and orthogonal functions, including the proof of the convergence theorem in the case of piecewise very smooth periodic functions. The text includes chapters on ordinary and partial differential equations. The 130 pages devoted to complex variables comprise an excellent text for an introductory course in complex function theory. Such topics as the Cauchy integral theorem, power series, residues, and conformal mapping are included.

Much is added to the appearance of the book by its beautiful illustrations. A long list of problems accompanies each topic presented, as well as a list of references suggesting further reading for the student. Here is indeed an excellent advanced calculus book.

GEORGE SPRINGER

Northwestern University

Chemical Calculations. Sidney W. Benson. 211 pp. $2.95. Wiley, New York. 1952.

AN INTRODUCTION to the mathematics of chemistry, this book is designed for the beginning student in this field, with special emphasis on the problems encountered in the first two years of college chemistry.

The first chapter discusses simply and clearly such subjects as measurement, intensive and extensive properties of matter, relations between different properties, a general method for solving problems, and property conversion factors.

Each of the subsequent sixteen chapters takes up the problems encountered in various phases of chemistry. Calculations are explained in great detail, and an adequate number of practice problems is included at the end of each chapter for the student. The importance of including units in the calculations is stressed throughout.

Appendix I covers such mathematical concepts as exponents, logarithms, and significant figures. Appendix II contains tables of equivalent metric and English units of measurement. Appendix III contains answers to the problems at the end of each chapter.

The text and the problems are, unfortunately, not free of misprints and errors.

L. M. ROTH

Department of Physics
Purdue University

Botany. Carl L. Wilson. 483 pp. Illus. $6.10. Dryden Press, New York. 1952.

THIS book is written primarily for the general student, and is "intermediate between certain texts which have oversimplified the subject matter and others which are planned principally to lay the foundation for advanced courses".

Organized along conventional lines, the first half is largely devoted to elucidation of the structure and function of higher plants, and the second half to a survey of the plant kingdom, with emphasis on the

evolutionary aspects. Treatment of subject matter is probably thorough enough for most elementary botany classes, and where it is not the standard organization will make it easy for the teacher to fill in additional material.

Often in elementary textbooks one finds poorly qualified generalizations which fail to give the student the necessary appreciation of the immense variety in structure, morphology, physiology, and ecology of plants. Professor Wilson has avoided this error. He points out the exceptions along with the general rules and frequently indicates areas in which agreement is lacking and more research needed. Interpretations are on the whole sound and up to date.

Two introductory chapters give exceptionally good orientation to the reader. The first chapter places botany within the framework of science and society, the second gives the reader a bird's-eye view of what is to follow, how the parts fit together, and why each part is significant. The relationship between botany and the affairs of men is emphasized throughout the book.

Some examples among the 30 chapter titles give a clue to the approach and scope of this book: The Cell as a Basis of Plant Life; Plants and Water; The Root and the Soil; Growth and Movement; How Plants Inherit; The Algae; and Early Land Plants and their Evolution. A concise summary is given at the end of each chapter. A glossary defines the important technical terms.

From its green photographic binding to its last page, this book is pleasing to the eye. Its more than 500 photographs and line drawings (by Hannah T. Croasdale) are well chosen, of high quality, and attractively arranged. Page size is 7.5×10 inches, with type set in two columns. The text is not, however, as succinct and fast-moving as the layout would suggest.

In my opinion, the book is admirably suited to the general student and should have considerable appeal to conservationists and others who are interested in botany but who are not specialists. Such shortcomings as it may have for the potential botany major can easily be surmounted by a good instructor and a well-equipped laboratory.

ROALD A. PETERSON

Northern Rocky Mountain
Forest & Range Experiment Station
Missoula, Montana

Economic Botany. (2nd. ed.) Albert F. Hill. xii + 560 pp. Illus. $7.00. McGraw-Hill, New York. 1952.

IN THE fifteen years since the first edition of this book in 1937, changes in the status of and additions to our economic plants have required many text changes to bring the subject matter up to date, which seems to have been very well done. The twenty-one chapters have been grouped by subjects as follows:

Introduction: The Importance of Cultivated Plants.

Industrial Plants and Plant Products: Fibers and Fiber Plants; Forest Products (wood and cork); Forest Resources; Tanning and Dye Materials; Rubber and other Latex Products; Gums and Resins; Essential Oils; Fatty Oils and Waxes; Sugars, Starches and Cellulose Products.

Drug Plants and Drugs: Medicinal Plants; Furnitories and Masticatories.

Food Plants: The History and Nature of Food Plants; The Major Cereals; The Minor Cereals and Small Grains; Legumes and Nuts; Vegetables; Fruits of Temperate Regions; Tropical Fruits.

Food Adjuncts: Spices and other Flavoring Materials; Beverage Plants and Beverages.

These are followed by an appendix which includes a 26-page Systematic List of Species Discussed; four pages of Bibliography; three pages of a List of Visual Materials and Directory of Sources; and a 30-page index.

The limited number of pages in the volume has necessitated too brief a treatment of the many important economic plants included, but references to more extended treatments of many of them will be found in the bibliography. The bibliographical references have largely been confined to books published on the more important crop plants, and it was not feasible to include the hundreds of special bulletins published by the government departments and commercial and technical organizations. References to most of these can only be found in the libraries that maintain a minutely classified card index to such publications, or by searching through the volumes of *Biological Abstracts* and of the *Bibliography of Agriculture* of the U. S. Department of Agriculture.

PERCY L. RICKER

The Wild Flower Preservation Society, Inc.
Washington, D. C.

Land for Tomorrow: The Underdeveloped World. L. Dudley Stamp. 230 pp. Illus. $4.00. Indiana University Press, Bloomington; American Geographical Society, New York. 1952.

THE jacket of this book informs us that "Dr. Stamp shows conclusively that the most important underdeveloped lands are *not* in the tropics and uninhabited latitudes, as we might expect; the hope for land development lies in the middle latitudes." With this thesis there may be some argument, yet the difficulties inherent in developing tropical areas for food production, and the questionable returns from such development, as set forth by the author, will have general acceptance.

Stamp is almost gentle in calling to our attention the evils, particularly the ruthless soil mining and soil erosion, of the agriculture of the United States. As a remedy he suggests "balanced mixed farming, with rotation of crops and carefully managed permanent pasture, with relatively small ten-acre fields but a high degree of mechanization." This is the English system of farming and serves well in that country. But Stamp says of southwest England: "The farmer, bearing all the responsibility and the burden of possible failure, is worse off financially than his hired man." Large-scale machine-farmed agriculture, in which the output per

man-hour is high, is termed the "hallmark of inefficiency." But the author has not addressed himself to the following problem: The abandonment of vast areas of submarginal and marginal land which could not be farmed in ten-acre fields. Such lands are farmed only by extensive methods. In areas where pressure is greatest on the land, such as China, and where yields per acre are high, marginal land lies idle.

A second problem is that of profit in farming. There remain today some societies and some nations in which the entrepreneur must make a profit. It is realized that the only true profit from agriculture is ultimate and continued maximum production for mankind from each unit of land. Irreplaceable basic assets should not be sacrificed on the altar of private profit.

A third problem is that of what man will do with his agricultural resources, as compared with what can be done. Dr. Stamp could not be expected to take up the culture (or the mulishness, some would say) of man as a determinant of agricultural practices, but its importance should be recognized.

A million copies of this book, each copy read by ten persons, would give insufficient circulation of its message. It should be read as a look beyond today.

GABRIEL P. BETZ

Department of Geology and Geography
The University of Buffalo

The Water and the Power: Development of the Five Great Rivers of the West. Albert N. Williams. xiv + 378 pp. $4.50. Duell, Sloan & Pearce, New York. 1951.

THE author states his method candidly and warns about incompleteness of data: "This book has been written the way modern painters paint—with a splash of color here, the suggestion of form there; with mass and weight, shade and shadow, sketched in as briefly as possible to give a total impression rather than any complete detail" (p. xiii). But the five chapters on the five rivers are not as bad as might be expected to result from this formula. This example applies to the Missouri Valley: "More people have known less about it and have made decisions of greater importance on the basis of that ignorance than any other major matter in our history. . . . Only one state, South Dakota, has even tabulated what it does *not* know" (p. 205).

The principal conclusion and the focus of the book are found in Chapter 7, A Future for America. A conviction of inevitableness pervades this chapter, which does not appear to be the logical consequence, necessarily, of the facts presented—a conclusion that the future system for the whole United States will be one of nine Valley Authorities, not isolated and competing, but integrated under a federal department of water development. The technique employed is not unique to this book, and the public does not appear to sense its implications—a manipulation of words to create "a total impression," primarily emotional, even irrational —but the method has become widely accepted, if not actually fashionable, among those who insist upon clothing discussions of historical and social questions in what is called, euphemistically, good literary form.

J. C. MALIN

Department of History
University of Kansas

Zoology in Postage Stamps. W. Dennis Way and O. D. Standen. vii + 113 pp.; 32 plates. $5.00. Philosophical Library, New York. 1952.

PICTURES of animals as well as plants have long been used on postage stamps and have become very popular with some collectors. Some of the classic ones, such as the Newfoundland dog, the Australian black swan, the Canadian beaver, and the American bison, were popular with philatelists of the past century. Sometimes packets containing only stamps bearing animal pictures are sold. The pictures themselves cover the whole field of zoology, from the gorilla down to mosquitoes, bees, and white ants, and even scallops and clams. Twelve different kinds of antelopes have been depicted, eight different kinds of bears, seven different kinds of eagles, and numerous others in heraldic forms which can be referred to only as eagles. From Mozambique comes a series of excellent drawings of twenty-four different species of marine fish.

The authors, W. Dennis Way and O. D. Standen, the former a philatelist and the other a zoologist, have attempted to correlate these pictures with the animals themselves, a sort of philatelic zoology. Short paragraphs describe the various subjects. The book contains nearly 300 black-and-white reproductions of the stamps, some of which are accurate pictures of animals and others rather impressionistic.

There are a number of errors in the labeling of the stamps; for instance, the well-known coatimundi on the Canal Zone stamp is not a raccoon, although it does belong to the same group of animals.

Zoology in Postage Stamps is a novel and interesting way of combining two subjects, and will be enjoyed by hobbyists in both fields.

W. M. MANN

National Zoological Park

Texas Range Grasses. Benjamin Carroll Tharp. xiv + 125 pp. Drawings by Clare Y. Whaley. $4.00. University of Texas Press, Austin (a publication of the Plant Research Institute). 1952.

THIS is a well-presented treatise on some of the more worth-while native grasses of Texas. It contains 125 pages, including two appendices and a bibliography. In addition there are five maps giving topography, average annual precipitation, vegetational regions, precipitation/evaporation figures, and soils of Texas, as well as 25 line drawings of single culms.

A commendable feature of the book deals with vegetational regions of the state and points out that each plant association reflects the character of the environmental conditions under which it has been able to de-

velop and maintain itself. These 18 vegetational regions in the state are outlined, and prominent shrubs and small tree components of each region, as well as the subordinate plants, are listed along with the grasses. Each region is summarized as to topography, climate, and soils. The grasses are listed as to respective ranks in relative abundance. From the accompanying numerical rating key, one can determine those grasses in the area which are dominant, subdominant, common but not abundant, infrequent in occurrence, or comparatively rare. In considering the plant distribution, relative humidity, evaporation factors, soils, precipitation, geology, and temperature play important roles.

The two appendices are quite worth while. Appendix I, in tabular form, summarizes results of a comparison of chemical analyses of 30 native grass species from those geographic and vegetational regions that have been subjected to analyses. Figures in the table represent average percentages of protein, phosphoric acid, and lime found in young material except where otherwise stated, where various stages of growth, such as blooming, medium, and mature, from three Texas regions (Northwest, Gulf Coast Prairie, and East Texas Timber Country) are given. The author presents herein a study of the factors that govern a grass species' adaptability and the relation of certain aspects of mineral nutrition to the growth and development of key Southwest grass species, the importance of environmental factors in the modification of the pattern of growth and development, and the nutritive value of some of these species. The data presented indicate that there is considerable difference in the ability of the grass species listed to absorb essential nutrients from the soil.

Appendix II, a comprehensive analytic list, gives distribution and relative abundance of the more important species of grass, from which the reader may compare pertinent results by referring to the numerical key and regional descriptions.

This is a very usable book which should be of particular value to research workers as well as to students in agronomy and ecology.

MASON A. HEIN
Division of Forage Crops and Diseases
Bureau of Plant Industry, Soils, and Agricultural Engineering, USDA
Beltsville, Maryland

An Introduction to Acarology. Edward W. Baker and B. W. Wharton. xiii + 465 pp. Illus. $10.00. Macmillan, New York. 1952.

THIS is the first comprehensive manual on the subject that has appeared in many years. The introduction discusses field and laboratory methods of study, gives a brief history of the literature on the subject, a detailed account of the anatomy, and a general classification.

This is followed by a discussion of each of the 228 families, with dichotomic keys to the families and lists of the genera, and economic and biological data, illustrated with 377 excellent line drawings.

With the increased importance of and interest in mites and ticks in connection with agriculture, public health, and medicine, this book will be welcome to all professional workers in these fields and to the layman interested in biology—a valuable text for students and a useful handbook for workers in pest control.

W. M. M.

The Scientific Work of René Descartes (1596–1650). J. F. Scott. x + 211 pp. £1. Taylor & Francis, London. 1952.

THE *Discourse on Method,* familiar to every college student of philosophy, was originally an introduction to a larger work in three parts—*La Dioptrique* (Optics), *Les Météores* (Meteorology), and *La Géométrie* (Analytical Geometry)—to prove the worth of the method. Scott's book is largely a paraphrase and analysis of these scientific treatises, with most pages devoted to *La Géométrie.* There is also an analysis of the *Principia Philosophiae:* Descartes' epistemology, cosmology, and basic physics. Astonishing as it may be, Scott is the first author to make the Cartesian science, as distinguished from metaphysical first principles, available to the English-reading student.

Descartes' supreme achievement, Scott makes plain, was the perception that mathematics is necessary to science. Nature he saw as a machine operating according to the laws of mathematics. His weakness, Scott also emphasizes, was the shortcoming of a mathematician: he tried to give an a priori account of nature, to unravel nature out of his mind as a mathematician does theorems, without paying due respect to the laboratory or observatory.

As one might anticipate, Descartes in his efforts in the various sciences was most successful in pure mathematics. Here he was one of the inventors of analytical geometry, which helped pave the way for the calculus of Newton and Leibniz. He was relatively successful in theoretical optics, a natural proving ground for the geometer. Here, though he was not the discoverer of the law of refraction, he traced its applications farther than his predecessors.

But in other branches of physics, where appreciation of the critical and decisive role of experiment and observation is indispensable, Descartes was relatively unsuccessful. Certain of his preconceptions closed the door to him. He thought it axiomatic, for example, that matter is extension and nothing more. Thus he had to hold that empty space is an impossibility and that the very idea of an atom is absurd. These a priori notions had an unfortunate effect on his basic physics. Action-at-a-distance was unthinkable to him, making it irrational for several generations of his disciples to accept Newton's doctrine of gravitation. In his system there was no place for mass, a property of matter important in the history of physics from the time of Newton. Without mass Descartes had nothing to measure

force by, so that his idea of force was a metaphor. For atoms he substituted vortices or whirlpools in the continuum of matter, by which he tried to explain stellar and planetary motions, origins, and evolution. The doctrine of vortices, under the influence of Newton, proved dynamically untenable.

When we come to Descartes' consideration of specific problems of experimental and observational physics, we cannot help but be amazed at his successes and tolerant of his failures. His work on the rainbow was definitive. He suspected that air has weight and proposed the correct reason for the suspension of liquids in tubes. His theories of light and heat are along modern lines. His accounts of magnetism, static electricity, and geological and meteorological processes are at least mechanical. But his formulation of the laws of motion went askew. These laws, like his treatment of color, collapsed before Newton. Descartes gave an odd twist to the Copernican theory. *Terra firma* is actually firm as the Church required. At the same time she swings around Old Sol. A vortex does the swinging, and the earth remains fixed at one place in the vortex. Descartes' speculations on the primary elements are of little value. His most unsuccessful ventures were in physiology, where he made innumerable factual errors.

The Cartesian system had remarkable vitality. Nearly two centuries were required for the followers of Newton to dislodge it.

RUFUS SUTER

Army Map Service
Washington, D. C.

Symposium on Biochemistry of Nucleic Acids. 245 pp. Suppl. 1, *Journal of Cellular and Comparative Physiology*, Vol. 38, July 1951.

THE pressure for publication in scientific journals obliges editors to limit the space made available to any author and for the presentation of material dealing with any one subject. The Editorial Board of the *Journal of Cellular and Comparative Physiology* has approved, on a trial basis, the publication of occasional supplements. The articles published must "meet the usual standards of scientific merit; the authors must provide the full cost of publication."

The supplement here reviewed comprises articles and pertinent discussion presented at a conference held in Oak Ridge in 1950. The material included relates to the chemistry, the distribution and significance in the living cell, and the anabolism, the biological synthesis, of the nucleic acids and their derivatives.

The chemical synthesis of the ribonucleosides and the ribonucleotides is considered. W. E. Cohn summarizes results with ion-exchange chromatography which have led to the discovery of isomeric nucleotides. "Types" of nucleic acid, as characterized by variation in the ratios between groups of purines and pyrimidines, are described by Chargaff. Partial enzymatic hydrolysis has been applied by G. Schmidt and associates to gather information concerning intramolecular sequence of the building units, and the results are outlined here. The determination of the desoxyribonucleic acid content of nuclei by the cytological method of photometric analysis of individual nuclei is described. In most of the observations "the amount of desoxyribonucleic acid per nucleus appears to be parallel with the number of sets of chromosomes, and, presumably, also with the number of sets of genes." Evidence that nucleic acid derivatives exhibit regulatory mechanisms in two microbiological growth systems is presented by Skeggs. G. B. Brown reports that "certain free purines are used for the biosynthesis of nucleic acids but their derivatives, as occurring in pentose nucleic acid, are more extensively catabolized and are but poorly utilized for nucleic acid production. In contrast, the pyrimidines, cytosine and uracil, are not utilized for nucleic acid synthesis while ribose derivatives are so utilized." The origin and metabolism of ribose are comprehensively reviewed (Scott and Cohen). Two articles deal with the biosynthesis of the purines and pyrimidines, Shive considering especially the role of the B vitamins. Buchanan concludes, "The fact that pyrimidines and purines, substances of very similar structure, have different precursors and are therefore probably synthesized by entirely different mechanisms has proved to be one of the most interesting developments of the isotopic work on this class of substances."

This interesting monograph is available to scientific investigators in the nucleic acid field, free of charge, from the sponsors, the Biology Division, Oak Ridge National Laboratory.

R. C. CORLEY

Department of Chemistry
Purdue University

Wild Flowers for Your Garden. Helen S. Hull. 280 pp. Illus. $4.95. M. Barrows & Co., New York. 1952.

NOW that our cities are spreading out and encroaching upon the woodlands, there is very real danger that wild flowers will be exterminated. To conserve them and perpetuate their beauty, Mrs. Hull —former president of the National Council of State Garden Clubs—would have us bring them into our gardens. It might be easier to tell the ambitious grower of a woodland garden what is not in this enthusiastic book than to note all the helpful things in it.

For here, with many pages of gorgeous full-color illustrations, are all the directions to make a lovely spot "where plants native to the United States are arranged in pleasing design and grown under conditions to suggest their natural state." Mrs. Hull emphasizes the fact that our attention must be on our own wild flowers and that foreign introductions are to be excluded. She makes it clear that there is "a typical order of plant succession" for any given situation, and that success is assured those gardeners who follow nature's plan.

A beautiful garden attracts birds, butterflies, and

fireflies. It may be planted in a city lot or a larger acreage. Wherever it may be, a rock garden is possible; suitable plants and their arrangements are listed. Plants for full sun are named and those for pond and bog, with the right conditions of soil, shade, moisture, etc. Trees for temperature control, ferns for beauty and moisture control, violets for their universal appeal, are added to the detailed suggestions. Among the stimulating ideas is a "wonderglobe;" even an apartment dweller may have a wild flower garden in a covered glass bowl.

The second part of the book contains contributions from gardeners in each of the forty-eight states. From the cactus gardens of Arizona and New Mexico, to the columbines of Colorado, the alpines of Oregon, and the Jack-in-the-pulpits of the east coast, come specific and encouraging instructions. If you have a wild flower garden now, you will welcome this entrancing book. If you have none, you will be inspired to start one at once.

MARJORIE B. SNYDER

Washington, D. C.

A Source Book in Chemistry 1400–1900. Henry M. Leicester and Herbert S. Klickstein. xvi + 554 pp. Illus. $7.50. McGraw-Hill, New York. 1952.

THIS is the seventh book to appear in the series of "Source Books in the History of the Sciences," the first of which was published about twenty years ago. In the preface, Leicester and Klickstein state that the preparation of the present volume was originally begun before World War II and that they took over in 1948. They adopted as their standard of selection "material which illustrates the development of chemical theory only." In carrying out their great task they sought and used the advice of "scholars and historians of chemistry," whom they list in the preface. The work of 82 authors is represented by a few paragraphs or a few pages, each introduced by a concise description of its outstanding features and its place in the history of chemistry. Complete bibliographical descriptions of the sources from which they quote, and an extensive list of references to biographies, indicate how thoroughly the editors did their work. The result is a valuable and enjoyable collection of signposts on the fascinating way of chemistry through the ages.

The selections start with the book on metallurgy by Biringuccio (1480–1539), posthumously published in 1540. The beginning in 1400 mentioned on the title page must therefore be taken not as a promise but as a formality only. The editors describe chemical developments before 1540 in an introduction of three pages, which necessarily uses some short cuts. The statement on page 3 that the mercury-sulfur theory "arose among the Arabian alchemists" neglects the Greek and Alexandrian origins of the theory and may thus be somewhat misleading.

Leicester and Klickstein are a little too positive concerning the author who preferred to hide behind the name Basil Valentine (around 1604). In general, the authors and quotations are well selected according to the standard set up by the editors, but in some instances, this very commendable standard could have been applied more rigorously. In the material taken from Liebig's work there are more fundamentally important parts than those reproduced here. I feel that Liebig, Berthelot, Baeyer, and Ostwald should have been better represented, and I miss Schönbein and Crookes.

These and other details need not be discussed further, however; it is more important to point out the positive achievement of the editors. They have brought the sources of chemical theory within the reach of everyone. Students and teachers, and all those who are searching for a deeper understanding of this or any other science, will find this book a valuable tool.

EDUARD FARBER

Washington, D. C.

Forest Inventory. Stephen H. Spurr. xii + 476 pp. Illus. $8.50. Ronald, New York. 1952.

Forest Management. H. Arthur Meyer, Arthur B. Recknagel, and Donald D. Stevenson. xii + 290 pp. Illus. $6.00. Ronald, New York. 1952.

SPURR's book describes briefly the measurement of trees and forest stands, and comprehensively the estimation of tree volume and growth. Sampling and inventory design also receive rather thorough consideration.

Part 1, in addition to the usual presentation of tree measurements and the type of sample plots used by foresters, contains a general discussion of the measurements feasible on aerial photographs. Part 2 contains 162 pages and discusses exhaustively the methods and problems encountered in tree volume determination. Both cubic and board foot volume are covered. The last two chapters in this section consider volume tables for use with aerial photographs and the direct estimation of stand volume.

Part 3 (168 pages) considers tree growth determination by continuous inventory, stem analysis, stand-table projection, yield tables, and growth tables based on density and site. The last chapter in this section develops an ideal two-way growth prediction method, based upon separate predication of basal area growth and height growth. The fourth part (70 pages), on sampling and design, briefly covers the theory of sampling as it applies to forest inventory both from ground and photographic surveys.

The 30-page, 8-pica bibliography attests to the exhaustive character of the presentation, a presentation of great value to the research worker and graduate student. Obviously, its comprehensive nature will make it a valuable reference work, but will limit its use as an undergraduate textbook.

Forest Management is divided into four parts: a brief discussion of objectives and the history of forest

management, then five chapters on general organization, four on forest regulation, and, finally, four more on management plans. It follows the traditional European presentation first introduced into this country by one of the authors forty years ago, but gives much less space to German methods of regulation.

Part 2 briefly discusses various economic, mensurational, and administrative aspects of forests as they affect management. The several managerial subdivisions of forests are defined, such as the working circle, working group, logging chance, block, and compartment. A sample timber sales contract is reproduced.

Forest regulation, comprising 108 pages (more than a third of the book), begins with a discussion of sustained yield and is followed by a detailed exposition of normal forest concept. Methods of determining the allowable cut, which in former books on forest management occupied many pages, is covered in 23 pages because "most older methods of forest regulation have become obsolete." The only methods described fully are the normal volume, growth, cutting percent, and the stand method.

Among the types of forms for management plans presented as illustrations are two of small properties, two of lumber company holdings, and one for a working circle on a national forest. All of them are for forest land in the East or the South.

Students will welcome this addition to forest management literature. Except for the usual mistake of placing the chapter on history near the beginning of the book, where it cannot be understood until subsequent chapters are mastered, professional students will find the book an excellent text for the management of forests for timber production. However, students and forest managers interested in managing a multiple-use forest property will find the same fault in this text, common to all older books of its kind, that it barely mentions other uses and should, therefore, be entitled "Management of Forests for Wood Production."

PAUL A. HERBERT

Division of Conservation
Michigan State College

NEW BOOKS

Adolf von Baeyer, 1835–1917. Karl Schmorl. x + 214 pp. Illus. 12.50 DM. Wissenschaftliche Verlag, Stuttgart. 1952.

The Organ, Its Evolution, Principles of Construction and Use. William Leslie Sumner. xiii + 436 pp. Illus. $10.00. Philosophical Library, New York. 1952.

Technical Reporting. Joseph N. Ulman, Jr. xiv + 289 pp. Illus. $3.50. Henry Holt, New York. 1952.

The Living Body. (3rd ed.) A text in human physiology. Charles Herbert Best and Norman Burke Taylor. viii + 792 pp. Illus. $5.50. Henry Holt, New York. 1952.

Functional Anatomy of the Mammal. (2nd ed.) A Guide to the Dissection of the Cat and an Introduction to the Structural and Functional Relationship between the Cat and Man. W. James Leach. x + 276 pp. Illus. $4.50. McGraw-Hill, New York, Toronto, London. 1952.

Panorama of Science, 1952. Annual supplement to the Smithsonian Series for 1952. Webster Prentiss True, Ed. ix + 422 pp. Illus. (No price given.) Series Pub., New York. 1952.

The Story of Watches. T. P. Camerer Cuss. 172 pp. Illus. $7.50. Macgibbon & Kee, London; Philosophical Library, New York. 1952.

Trees and Shrubs in Eastern North America. Keys to the Wild and Cultivated Woody Plants Growing in the Temperate Regions Exclusive of Conifers. Benjamin Blackburn. xv + 358 pp. Illus. (No price given.) Oxford University Press, New York. 1952.

Practical Psychology. (Rev. ed.) F. K. Berrien. xv + 640 pp. Illus. $5.00. Macmillan, New York. 1952.

The Rational and the Superrational, Vol. II. Cassius Jackson Keyser. viii + 259 pp. $4.25. Scripta Mathematica, Yeshiva University, New York. 1952.

Religious Faith, Language, and Knowledge. A Philosophical Preface to Theology. Ben F. Kimpel. x + 162 pp. $2.75. Philosophical Library, New York. 1952.

Backgrounds of Human Fertility in Puerto Rico. A Sociological Survey. Paul K. Hatt. xxiv + 512 pp. $5.00. Princeton University Press, Princeton, N. J. 1952.

Flora of Guatemala. Fieldiana: *Botany,* Vol. 24, Part III. Paul C. Standley and Julian A. Steyermark. 432 pp. $4.50. Chicago Natural History Museum, Chicago. 1952.

Lepidópteros, 2ª parte. Tomo VI, *Insetos do Brasil.* A. da Costa Lima. 420 pp. Illus. Escola Nacional de Agronomía, Rio de Janeiro. 1950.

Biochemical Preparations, Vol. II. E. G. Ball, Ed. vii + 109 pp. $3.00. Wiley, New York; Chapman & Hall, London. 1952.

Spatial Vectorcardiography. American Monograph Series. Arthur Grishman and Leonard Scherlis. xi + 217 pp. Illus. $6.00. Saunders, Philadelphia and London. 1952.

The Auricular Arrhythmias. Myron Prinzmetal *et al.* xix + 387 pp. Illus. $16.50. Thomas, Springfield, Ill.; Blackwell Scientific Pub., London; Ryerson, Toronto. 1952.

Die Chirurgie des Dickdarms. Hans Finsterer. 382 pp. $12.50. Verlag Wilhelm Maudrich, Wein-Dusseldorf. 1952.

Surgery and the Endocrine System. James D. Hardy. xii + 153 pp. Illus. $5.00. Saunders, Philadelphia and London. 1952.

Parasitism and Symbiosis. Maurice Caullery. xii + 340 pp. Illus. $5.50. Sidgwick & Jackson, London. 1952.

Introduction to the Study of Physical Chemistry. Louis P. Hammett. xii + 427 pp. Illus. $6.00. McGraw-Hill, New York. 1952.

Vinyl and Related Polymers. Calvin E. Schildknecht. xi + 723 pp. Illus. $12.50. Wiley, New York; Chapman & Hall, London. 1952.

Five-Membered Heterocyclic Compounds with Nitrogen and Sulfur and Nitrogen, Sulfur and Oxygen. Vol. IV, *The Chemistry of Heterocyclic Compounds.* L. L. Bambas. Arnold Weissberger, Ed. xi + 403 pp. Illus. $14.00; $12.60 by subscription. Interscience, New York and London. 1952.

CORRECTION.—The price of *Life in a Mexican Village,* by Oscar Lewis, reviewed by Kingsley Davis (*Sci. Monthly,* 74, 368 [1952]), was changed prior to publication. The correct price is $7.50–not $5.00 as listed in the review.

LETTERS

REGARDING AIMLESSNESS IN EDUCATION

As a teacher of biology who has just resigned after two schizoid years of trying to maintain intellectual honesty in a school that has divorced itself from such an educational responsibility, I find myself in Dr. Arthur E. Bestor's camp. However, his article, "Aimlessness in Education" (The Scientific Monthly, **75**, 109 [1952]), is so completely one-sided that it loses some of its effectiveness. In fact, I feel compelled to put myself in the awkward position of defending some aspects of the very system I abhor.

One of the most important reasons for the current trend in education is the fact that the traditional, conservative, classical approach, in its attention to scholarship, often neglected the human being. First, scholastic requirements were too rigid, and, because of this, students mentally less able than others were being denied the education to which they were entitled. Second, it became obvious that scholarship alone could not equip the individual to assume his place among the responsible citizens of the world. Third, it also became obvious that scholarship alone could not equip the individual to adjust himself to a society in which rapid technological progress and enormous consumption of natural resources were bringing about vast changes in ethical conduct.

Realizing that scholastic demands had to be modified to fit the needs of the individual, and that the child and the youth were not receiving a liberal and reasoned moral foundation from their education in the home, the church, or in many colleges (a surprising number of colleges seem to think that a training for a profession is a substitute for a liberal arts education), the schools undertook these functions. Their idea was valid, and it remains so today. But a group of so-called educators, who interpreted, reinterpreted, and misinterpreted the philosophy of a man named Dewey, went several steps further. These men began to analyze teaching methods in the light of the newly discovered needs of students. They invented a number of wonderful-sounding catch phrases and a new branch of psychology to explain them. And they started a new system of education that damned as authoritarian and doctrinaire those teachers and schools that did not conform to the theory that the student need only learn what he wants to learn. This was a system of education which, in its fanatic haste to assert itself as revolutionary and important, forgot all about scholarship, intellectual discipline, and other real values that, strangely enough, were often inherent in the conservative approach.

Because of these people, we do indeed have today a situation in many public schools, college education courses, and some private schools that threatens the very nature of education; it denies youth those intellectual obstacles the overcoming of which is essential to the development of the mature mind. Dr. Bestor has described this danger with examples that are terrifyingly true, but he has engulfed good as well as evil in his sweeping condemnation of the changes that have been made in education; and he has stated his case in such a way as to imply that *all* public schools have fallen prey to the "progressive" system. The latter, fortunately, is not true. But if this very real assault by the professional educators on the intellectual ramparts is to be stopped, the battle against it must be waged with our own weapons, those of intellectual objectivity, and not with the weapons of the professional educator, those of the traducer.

Edward O. Shakespeare
Waterloo and Sugartown Roads
Berwyn, Pennsylvania

I regret that you have chosen to publish another article of the Fuller type, "Aimlessness in Education," by Bestor, who is a colleague of Fuller at Illinois. A large part of this article reflects a bitter fight on the University of Illinois campus, and the essay as a whole seems to me a caricature unsuitable for publication in a scientific journal.

I suggest once more the wisdom of the cooperative point of view so aptly expressed by President Conant of Harvard.

Carter V. Good
University of Cincinnati Teachers College

The Scientific Monthly has scored a second bull's-eye in education in a little over a year (the first one was "The Emperor's New Clothes"). Better-documented than the first, and more direct in its criticism of the weaknesses of the "moderns," this article by Arthur E. Bestor, Jr., is far and away the best of its kind.

No doubt the professors of education are sharpening their axes for Bestor. It will be interesting to see with what cogency they meet his criticisms. If their defense is no better than the one offered to Professor Fuller's article, then shoddy indeed is their position.

I sense that this struggle for and in the public schools of America will soon grow to the proportions of a first-magnitude problem for us to solve. More hard-hitting articles of this type will help to direct attention to a sound solution.

Charles Salkind
Samuel J. Tilden High School
Brooklyn, New York

I AM interested in getting some copies of the article on "Aimlessness in Education," by Arthur E. Bestor, Jr. Will you please advise me how to get these and how much the cost would be for 25 copies, 100 copies, 200 copies?

PAUL MONTAGUE

Montague Tool & Manufacturing Company
Mount Morris, Michigan

"Aimlessness in Education," by Arthur E. Bestor, Jr., is a highly significant article. Will you please send me 25 reprints and bill to me.

WILLIAM W. PORTER II

244 South Gramercy Place
Los Angeles, California

DR. ARTHUR E. BESTOR'S outburst, entitled "Aimlessness in Education," must be taken seriously by all concerned with education, and particularly by those *responsible* for the education of American youth. As a matter of good taste, one might call into question the author's use of invective, irony, sarcasm, and name-calling. But, obviously, he is not grinding the ax of any organized group engaged in the current pastime of taking pot shots at public education. The author speaks sincerely and in the name of high principle.

Dr. Bestor very ably exposes some rather sorry examples of shoddy thinking in education and then condemns what, in derision, he calls the "professional educator." He notes, charitably, that there are some "honorable exceptions."

It could be a sobering experience for Dr. Bestor to be confronted with a class of high school children whose IQs hover about 70, and for him to be charged with the responsibility of developing their minds "to the greatest extent possible" by applying his formula: ". . . careful and systematic study of history, political science, philosophy, economics, sociology, and other relative disciplines." If he does not emerge from this experience with a greater respect for the professional educator, he will at least acquire a greater appreciation of some of the problems that professional educators have to grapple with. Incidentally, the proposed experience would be salutary, too, for some professors of education who, though they sit on a different academic limb from Dr. Bestor, seem equally removed from the educational facts of life. Many a professor of education —and many a school administrator—has, for *years* been out of direct contact with classes of honest-to-goodness flesh-and-blood children.

The task of educating in schools *all* youth in a complex civilization like ours is unprecedented in human history. It is naïve to believe that this formidable task can be carried out successfully by the application of any simple formula, however time-honored; nor can we afford to wait until such a formula is discovered. To quote from James K. Finch's brilliant review in the same issue of THE SCIENTIFIC MONTHLY ("A Century of Engineering Progress, 1852–1952"): "The engineer has never been able to wait until he had all the pertinent information before attempting to meet the material needs and wants of his day. The doctor does not refuse to treat a patient because he does not fully understand the disease from which the afflicted one suffers." One might add that the teacher does not give up in despair because he does not yet adequately understand what goes on (or what fails to go on) inside the skulls of the children sitting before him. Under the circumstances, there is bound to be some trial-and-error operation and even some blundering. Dr. Bestor concentrates his attention on the blundering. His hair stands on end. He gets the creeps. His emotional outburst is understandable.

Nevertheless, Dr. Bestor's emotionalized observations may serve a useful purpose; his remarks may alert us to the danger of losing sight of the effectiveness of the traditional curriculum for those children who *do* have the aptitudes to profit from such a curriculum. Above all, there is the danger that, in our eager scramble to meet the needs of those who cannot profit from the traditional curriculum, we might neglect the needs of the specially gifted children in our school population. These children represent the greatest potential for good or evil, and on *their* shoulders must eventually rest the most vital responsibilities in our society.

But most significant of all in Dr. Bestor's paper is his dramatic description of the "iron curtain" that, he asserts, stretches across the educational world. Dr. Bestor is presumptuous when he asserts that this "iron curtain" (more accurately described as an academic wall) was "fashioned by educators." The braces for this wall are mostly on the side of the professors of academic subjects in our colleges and universities. These gentlemen, completely immersed in their respective "fields," seldom take occasion, as Dr. Bestor has done, to look at what goes on in the "lower" schools. When they do take a look, it is down their noses. As professors of their respective disciplines, the doctors have a stake in what goes on in the schools; as the most thoughtful citizens in our communities, they have an obligation to contribute their best thought and advice toward the improvement of what goes on in our schools.

It is high time the learned doctors did more than they are now doing collectively to bridge the gulf that divides the academic from the educational departments in our universities. But to bridge the gulf the sides will have to approach one another in a spirit of sympathetic understanding, and in approaching the problems of educating children both sides must come with the feeling of humility that characterizes the true scientist when he is face to face with the baffling problems of nature. Dr. Bestor is to be commended for his concern with a vital problem, but in his paper the aforementioned spirit and feeling are notably lacking.

ZACHARIAH SUBARSKY

Bronx High School of Science, New York City

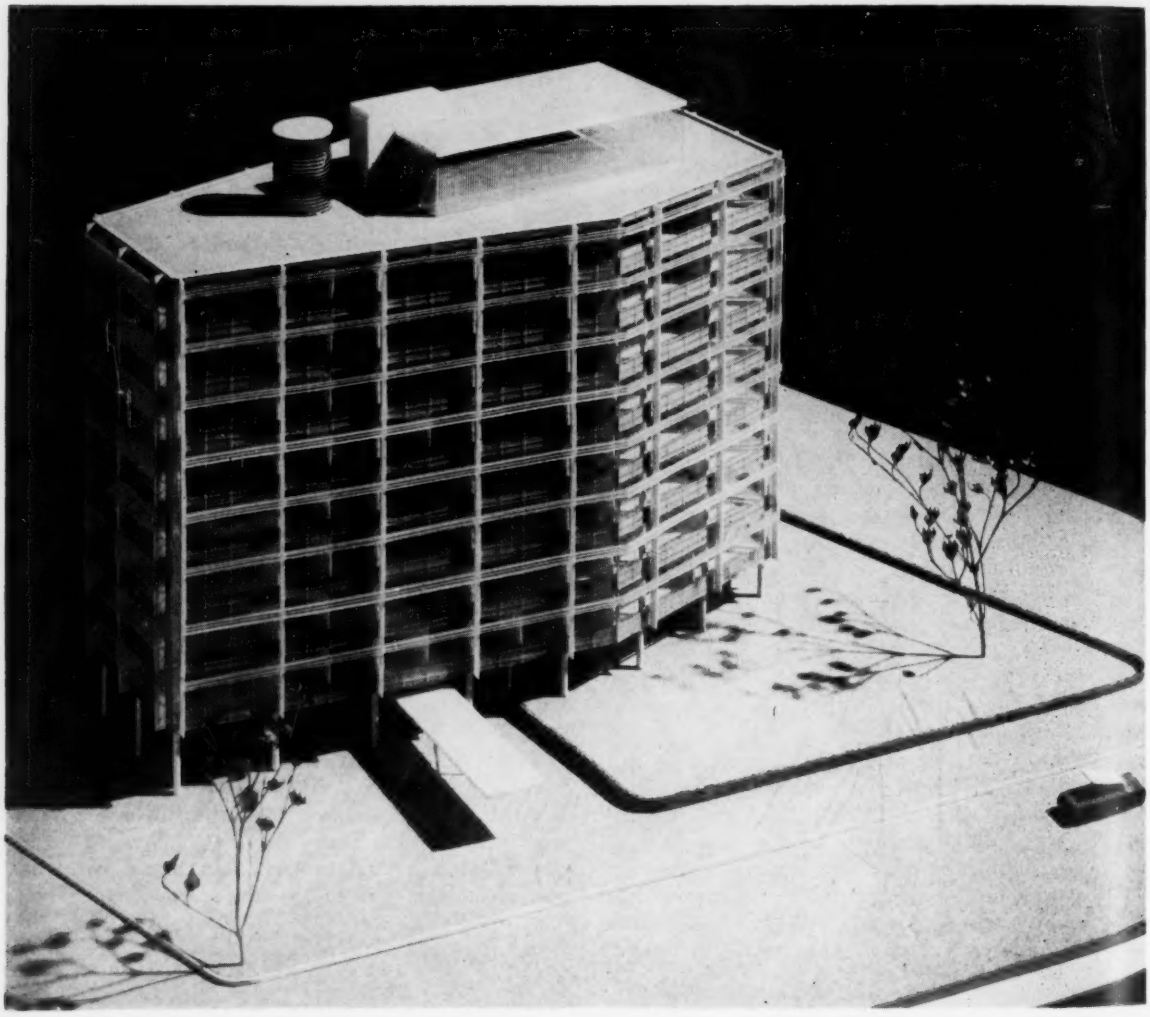
ASSOCIATION AFFAIRS

AAAS HEADQUARTERS

WITH the endorsement of the AAAS Council, the Building Committee has continued its work of planning for a new building, and John R. Dunning has been carrying on the task so energetically started under the chairmanship of Roger Adams, who retired from office on January 14, 1952.

In 1951 the Committee had tentatively concluded that a three-story edifice, designed to meet the Association's needs, was the best solution to the housing problem; but there has been a growing conviction that property is so valuable in this section of Washington as to warrant the maximum utilization permitted under the District's zoning regulations. The Architects Collaborative, of Cambridge, Massachusetts, was commissioned to design an appropriate building, and the result is pictured on the accompanying photograph of a scale model.

The irregular shape of the lot, the rigid limitations on the area available for construction, and the 90-foot zoning restriction on height dictated the prismatic form of the eight-story structure and will require the use of basement space below street level for the parking of approximately forty cars. Necessity bred ingenuity, for the result is a unique but attractive and dignified structure that will provide the Association with artistic and efficient headquarters. Initially, the first two floors will suffice for offices and conference rooms, and the six upper floors will be available to tenants—perhaps other scientific organizations that are seeking modern quarters in Washington.



The gap between plans and a building ready for occupancy is a wide one, not so much in time as in the means of execution. Application for permission to build this type of structure is even now before the District Zoning Commission. Problems of financing are being studied, and it is hoped that members and friends of the Association, whose generous response to a single letter in 1946 made the purchase of the site possible, will again assist substantially in minimizing the financial burden. The timing of construction calls for careful analysis of current conditions in the building industry and of the availability of structural materials, as well as an appraisal of future prospects. The rental of temporary quarters during the period of construction poses another set of problems, and due consideration must also be given to the occupants of residences on the property.

Nonetheless, it is believed that a complete project can be formulated soon, and that its soundness and good sense will win immediate approval of the Council and staunch backing from the entire AAAS membership.

AAAS PRIZES AND RESEARCH GRANTS

Prize in the Social Sciences. A prize competition for essays on theoretical sociology was offered in 1951 (*Sci. Monthly,* **73,** 338 [1951]), but in the opinion of the judges none of the entries adequately met the conditions established for the award, and no prize was given. A prize of $1000 is now offered for 1952 for essays reporting upon inquiry into the theory of social processes and group behavior. The conditions of the competition are as follows:

A. The contribution should further the comprehension of the psychological and cultural behavior of human beings in contemporary society, with specific recognition of the space-time frame of reference. The descriptions and interpretations presented should be developed from carefully controlled observations of actual social situations.

B. The development should be along those methodological lines that have been most prominent in the established sciences. Special attention in the particular case should be paid to the manner of theoretical-factual construction that can be studied in the line of progress from Charles Darwin through C. S. Peirce, William James, and John Dewey.

C. Clear recognition and steady stress should be given to observation as taking place always under postulation, and to postulation as always arising out of prior observation. If this view is not held, its alternative should be made scientifically clear. The essay should foster liberation from traditional philosophic-linguistic conventions and from outmoded boundaries between different social disciplines.

D. The focus of attention should be the process of movement and change in society, the interactions between individuals and groups, and the adjustments and readjustments in their relationships that make for activity and development.

Comment

This is not a prize for *conventional* work in the social sciences, even when done by the best conventional technicians; nor is it a prize for *any* kind of original work, no matter how brilliantly dialectical it may be. Fundamentally, it is a prize to encourage procedures within the framework of the best formulated evolutionary naturalism and experimental or operational logic of the past half-century or more.

Manuscripts will be judged by a committee of three persons who will be fully qualified to appraise material in this field, but who will not necessarily be sociologists. Entries should be sent to Howard A. Meyerhoff, Administrative Secretary, American Association for the Advancement of Science, 1515 Massachusetts Ave., N.W., Washington 5, D. C., not later than *October 31.* To facilitate the work of the judges, the *material should be submitted in triplicate,* and the name of the author should be omitted from the typed copy. Definite preference will be given to unpublished manuscripts or to essays especially prepared for this competition, but articles that have been published since December 1, 1951, will not be excluded from the competition merely by virtue of having been published. Announcement of the winner will be made at the Association's St. Louis meeting in December, but the Committee of Judges reserves the right to withhold the prize if no worthy assay is submitted.

Research Grants. In 1951 the AAAS awarded 46 grants-in-aid for research, using the income from its modest endowment funds, as well as special contributions received for this purpose. The amounts given each recipient were relatively small but, with the exception of two grants made by the Ohio Academy of Science to the Committee on Ohio Flora, they were given in support of individual projects. All but one of them were administered by affiliated academies of science, to each of which the AAAS remits $50 or a sum computed at fifty cents per academy member who is also a member of the Association, whichever amount is greater. Most of the academies have taken advantage of this arrangement, and a few of them match the amount made available from Association funds.

The AAAS administers the A. G. Stillhamer Endowment Fund, which was given for the pur-

pose of supporting research in biology. For several years the income from this fund has been allowed to accumulate, and the Association is now prepared to offer a $500 Stillhamer Grant for Biological Research in 1952. In subsequent years it will offer comparable grants of $500 in other scientific fields.

In addition to the Stillhamer Grant of $500, the Grants Committee will also consider applications for an award not to exceed $500, preferably in the field of science other than biology. This special grant is available for 1952 only, and it is not planned to offer it annually.

It is proposed to announce the 1952 awards at the St. Louis meeting of the Association, December 26–31, 1952, and applications will be received through *November 15.* Each application should provide the following information: name and address of applicant, his institution, a detailed description of the research project together with a statement regarding any progress thus far made, the specific purpose or purposes for which the funds are needed, the anticipated cost of the project, amounts and sources of other funds available for the project, and the names of two or more scientific colleagues who are sufficiently familiar with the project to advise the AAAS Grants Committee regarding it.

For the purpose of administering these annual grants, the AAAS Grants Committee will be revived, and the names of the members will be published in SCIENCE and THE SCIENTIFIC MONTHLY.

All applications should be submitted in triplicate to Howard A. Meyerhoff, Administrative Secretary, American Association for the Advancement of Science, 1515 Massachusetts Ave., N.W., Washington 5, D. C.

Prizes versus Grants. The lengthening list of prizes and grants administered by the Association has prompted a review of the relative merits of prizes, which are awarded for work already done and adjudged good, and of grants-in-aid, which are given on the basis of promise that significant work will be competently performed. At the present time the policy pursued by the Association is fortuitous, and in large part it reflects the wishes of the donors who have asked the Association to administer gifts or bequests. The current thinking of the Executive Committee favors the grant-in-aid, if only because the applicant, if adequately supported, may produce not merely something new, but something of the utmost significance in one of the fields of science. It should be noted that many of the recipients of prizes have turned the prize money back into research; few of them have regarded it simply as a windfall for which no further professional obligation was incurred. In retrospect there seems to be equal justification for the award of funds either to encourage research or to recognize it after it is done.

This year the awards that have been made or that will be made as a feature of the 119th Meeting of the AAAS at St. Louis, are sufficient in number to warrant listing, in order that readers of THE SCIENTIFIC MONTHLY may know more about this phase of the Association's activity and interest. Complete lists of past recipients will appear in the General Program and Directory.

AAAS Academy Research Grants ..... (administered by 38 affiliated state academies of science)	$7000
Special Academy Grants for Alabama and British Columbia ..... (for genetics and eugenics)	400
Stillhamer Research Grant in Biology	500
AAAS Research Grant ..... not to exceed	500
Newcomb Cleveland Prize ..... (for a paper of recognized significance presented before a scientific session at the annual meeting)	1000
Theobald Smith Award ..... (provided by Eli Lilly and Company for a distinguished contribution to medical science by a person under 35 years of age)	1000
AAAS—George Westinghouse Newspaper Science Writing Award	1000
AAAS—George Washington Magazine Science Writing Award	1000
AAAS Thousand Dollar Prize in Sociology .... (for sociological theory employing successfully methods used in the natural sciences)	$1000

HOWARD A. MEYERHOFF
Administrative Secretary, AAAS